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CLAIMS

[Claim(s)]

[Claim 1] Four optical circulators which are the optical circuits for an optical pass arrangement which have at least four extraneous light input/output port, and have said extraneous light input/output port, the input/output port connected, input port, and an output port, respectively, Four uni-directional optical amplification means to input the signal light from the output port of these optical circulators, respectively, and to amplify it, The optical circuit for an optical pass arrangement characterized by inputting the signal light outputted from these four uni-directional optical amplification means, respectively, and having the optical control means which controls the output to the input port of said optical circulator of this signal light.

[Claim 2] Said optical control means is an optical circuit for an optical pass arrangement according to claim 1 characterized by consisting of two light wave length multiplexing/demultiplexing circuits and two or more optical cross-connect ADODOROPPU switches.

[Claim 3] Said optical cross-connect ADODOROPPU switch The transparency joint port selection optical switch which chooses two or more inputted lightwave signals suitably, and outputs them from said one near light wave length multiplexing/demultiplexing circuit, The output crossbar actuation optical switch which inputs the lightwave signal from this transparency joint port selection optical switch, and changes and outputs an output destination change port suitably, The optical circuit for an optical pass arrangement according to claim 2 characterized by being constituted by the transparency joint port selection optical switch which chooses suitably the output destination change port where the lightwave signal from this output crossbar actuation optical switch is connected to said near light wave length multiplexing/demultiplexing circuit of another side, and outputs it.

[Claim 4] Said optical cross-connect ADODOROPPU switch The output crossbar actuation optical switch which changes and outputs two or more inputted lightwave signals for an output destination change port suitably from said one near light wave length multiplexing/demultiplexing circuit, The transparency joint port selection optical switch which chooses suitably two or more lightwave signals inputted from this output crossbar actuation optical switch, and outputs them, The transparency joint port selection optical switch which chooses an output destination change port and outputs suitably the lightwave signal inputted from this transparency joint port selection optical switch, The optical circuit for an optical pass arrangement according to claim 2 characterized by being constituted by the output crossbar actuation optical switch which chooses suitably the output destination change port where the lightwave signal from this transparency joint port selection optical switch is connected to said near light wave length multiplexing/demultiplexing circuit of another side, and outputs it.

[Claim 5] The 1st thru/or the 4th optical circulator in which each has the optical input/output port to which each of the 1st thru/or 4th extraneous light input/output port is

connected, optical input port, and an optical output port, The 1st four optical input/output port to which said the 1st thru/or each optical input port of the 4th optical circulator is connected corresponding to 1 to 1, and -- this -- with 1 which has the 2nd four different optical input/output port from the 1st four optical input/output port, or two or more light wave length multiplexing/demultiplexing circuits Among the 2nd four optical input/output port of said light wave length multiplexing/demultiplexing circuit corresponding to 1 to 1 in the 1st thru/or each optical output port of the 4th optical circulator [with each optical output port of said the 1st thru/or 4th optical circulator, and the 2nd four optical input/output port of said light wave length multiplexing/demultiplexing circuit] Connect and it has 1st thru/or 4th four uni-directional optical amplification means to amplify and output the lightwave signal spread in the direction which goes to the 2nd four optical input/output port of said light wave length multiplexing/demultiplexing circuit from the 1st thru/or each optical output port of the 4th optical circulator. It has the 1st thru/or 4th optical input port and 1st thru/or 4th optical output port. Signal light is made to penetrate between the 1st optical input port and the 2nd optical output port and between the 3rd optical input port and the 4th optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 1st optical input port and the 2nd optical output port and except between the 3rd optical input port and the 4th optical output port, and] Or signal light is made to penetrate between the 1st optical input port and the 2nd optical output port and between the 4th optical input port and the 3rd optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 1st optical input port and the 2nd optical output port and except between the 4th optical input port and the 3rd optical output port, and] Or signal light is made to penetrate between the 1st optical input port and the 4th optical output port and between the 3rd optical input port and the 2nd optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 1st optical input port and the 4th optical output port and except between the 3rd optical input port and the 2nd optical output port, and] Or signal light is made to penetrate between the 1st optical input port and the 3rd optical output port and between the 4th optical input port and the 2nd optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 1st optical input port and the 3rd optical output port and except between the 4th optical input port and the 2nd optical output port, and] Or signal light is made to penetrate between the 2nd optical input port and the 1st optical output port and between the 3rd optical input port and the 4th optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 2nd optical input port and the 1st optical output port and except between the 3rd optical input port and the 4th optical output port, and] Or signal light is made to penetrate between the 2nd optical input port and the 4th optical output port and between the 3rd optical input port and the 1st optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 2nd optical input port and the 3rd optical output port and except between the 4th optical input port and the 1st optical output port, and] Or signal light is made to penetrate between the 2nd optical input port and the 4th optical output port and between the 3rd optical input port and the 1st optical output port. And between the 2nd optical input port

and the 4th optical output port Whether signal light is intercepted among all the optical input port and optical output ports except between the 3rd optical input port and the 1st optical output port And switching circuit S1-j for 4 input 4 output optical cross-connects selectable to arbitration ($j = 1, 2, \dots, N$), Or it has the 1st thru/or 4th optical input port and the 1st thru/or the 4th optical output port. Signal light is made to penetrate between the 1st optical input port and the 2nd optical output port and between the 3rd optical input port and the 4th optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 1st optical input port and the 2nd optical output port and except between the 3rd optical input port and the 4th optical output port, and] Or signal light is made to penetrate between the 1st optical input port and the 2nd optical output port and between the 4th optical input port and the 3rd optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 1st optical input port and the 2nd optical output port and except between the 4th optical input port and the 3rd optical output port, and] Or signal light is made to penetrate between the 1st optical input port and the 4th optical output port and between the 3rd optical input port and the 2nd optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 1st optical input port and the 4th optical output port and except between the 3rd optical input port and the 2nd optical output port, and] Or signal light is made to penetrate between the 1st optical input port and the 3rd optical output port and between the 4th optical input port and the 2nd optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 1st optical input port and the 3rd optical output port and except between the 4th optical input port and the 2nd optical output port, and] Or all make signal light penetrate between the 2nd optical input port and the 1st optical output port and between the 3rd optical input port and the 4th optical output port, and excluding between the 2nd optical input port and the 1st optical output port and between the 3rd optical input port and the 4th optical output port Intercept signal light between **** input port and an optical output port, or signal light is made to penetrate between the 2nd optical input port and the 1st optical output port and between the 4th optical input port and the 3rd optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 2nd optical input port and the 1st optical output port and except between the 4th optical input port and the 3rd optical output port, and] Or signal light is made to penetrate between the 2nd optical input port and the 3rd optical output port and between the 4th optical input port and the 1st optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 2nd optical input port and the 3rd optical output port and except between the 4th optical input port and the 1st optical output port, and] Or signal light is made to penetrate between the 2nd optical input port and the 4th optical output port and between the 3rd optical input port and the 1st optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 2nd optical input port and the 4th optical output port and except between the 3rd optical input port and the 1st optical output port, and] Or signal light is made to penetrate between the 1st optical input port and the 3rd optical output port and between the 2nd optical input port and the 4th optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 1st optical input port and the 3rd optical output port and except between the 2nd optical input port and the 4th optical output port, and] Or signal light is made to penetrate between the 1st optical input port and the 4th optical output port and between the 2nd optical input port and the 3rd optical output port. And [whether signal light is intercepted

among all the optical input port and optical output ports between the 1st optical input port and the 4th optical output port and except between the 2nd optical input port and the 3rd optical output port, and] Or signal light is made to penetrate between the 3rd optical input port and the 1st optical output port and between the 4th optical input port and the 2nd optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 3rd optical input port and the 1st optical output port and except between the 4th optical input port and the 2nd optical output port, and] Or signal light is made to penetrate between the 4th optical input port and the 1st optical output port and between the 3rd optical input port and the 2nd optical output port. And between the 4th optical input port and the 1st optical output port Whether signal light is intercepted among all the optical input port and optical output ports except between the 3rd optical input port and the 2nd optical output port And switch SP-j for 4 input 4 output optical cross-connects selectable to arbitration ($j = 1, 2, \dots, N$), Or it has the 1st thru/or 4th optical input port and 1st thru/or 4th optical output port. Optical waveguide between the 1st optical input port and the 2nd optical output port and between the 3rd optical input port and the 4th optical output port An epilogue, Carry out termination of all the other optical input port and optical output ports, or optical waveguide between the 1st optical input port and the 2nd optical output port and between the 4th optical input port and the 3rd optical output port An epilogue, Carry out termination of all the other optical input port and optical output ports, or optical waveguide between the 1st optical input port and the 4th optical output port and between the 3rd optical input port and the 2nd optical output port An epilogue, Carry out termination of all the other optical input port and optical output ports, or optical waveguide between the 1st optical input port and the 3rd optical output port and between the 4th optical input port and the 2nd optical output port An epilogue, Carry out termination of all the other optical input port and optical output ports, or optical waveguide between the 2nd optical input port and the 1st optical output port and between the 3rd optical input port and the 4th optical output port An epilogue, Carry out termination of all the other optical input port and optical output ports, or optical waveguide between the 2nd optical input port and the 1st optical output port and between the 4th optical input port and the 3rd optical output port An epilogue, Carry out termination of all the other optical input port and optical output ports, or optical waveguide between the 2nd optical input port and the 3rd optical output port and between the 4th optical input port and the 1st optical output port An epilogue, Carry out termination of all the other optical input port and optical output ports, or optical waveguide between the 2nd optical input port and the 4th optical output port and between the 3rd optical input port and the 1st optical output port An epilogue, Carry out termination of all the other optical input port and optical output ports, or optical waveguide between the 1st optical input port and the 3rd optical output port and between the 2nd optical input port and the 4th optical output port An epilogue, Carry out termination of all the other optical input port and optical output ports, or optical waveguide between the 1st optical input port and the 4th optical output port and between the 2nd optical input port and the 3rd optical output port An epilogue, Carry out termination of all the other optical input port and optical output ports, or optical waveguide between the 3rd optical input port and the 4th optical output port and between the 4th optical input port and the 2nd optical output port An epilogue, Carry out termination of all the other optical input port and optical output ports, or optical waveguide between the 4th optical input port and the 1st optical output port and between the 3rd optical input port and the 2nd optical output port An epilogue, It corresponds to the light wave length channel whose either of one 4 input 4 output optical circuit S3-j ($j = 1, 2,$

--, N) of whether termination of all the other optical input port and optical output ports is carried out is the element of the set LO of a light wave length channel separately. It is arranged, respectively. Such switching circuit S1-j for a total of N 4 input 4 output optical cross-connects, SP-j Or it is the optical circuit for an optical pass arrangement where it comes to connect two or more optical input/output port of said light wave long multiplexing/demultiplexing circuit corresponding to 1 to 1 with each of all the optical input port of 4 input 4 output optical circuit S3-j and optical output ports, these optical input port, and an optical output port, respectively. It is a form about eight relatively prime sets A-1 whose optical input/output port of said light wave length multiplexing/demultiplexing circuit is the set about the light wave length multiplexing/demultiplexing to set LO[of a light wave length channel] = { λ_{daj} } (i= 1, 2, --, N), A-2, A-3, A-4, A-5, A-6, A-7, and A-8. The optical waveguide which accomplishes and connects the 1st input/output port by the side of multiplexing which is the element of which the set A-1 of the optical input/output port of a light wave length multiplexing/demultiplexing circuit, and the optical output port of the 1st uni-directional optical amplification means, The optical waveguide which connects the 2nd input/output port by the side of multiplexing which is the element of which the set A-2 of those other than set A-1 of the optical input/output port of a light wave length multiplexing/demultiplexing circuit, and the optical output port of the 2nd uni-directional optical amplification means, The optical waveguide which connects the 3rd input/output port by the side of multiplexing which is the element of the set A-1 of the optical input/output port of a light wave length multiplexing/demultiplexing circuit, and which the set A-3 of those other than A-2, and the optical output port of the 3rd uni-directional optical amplification means, The optical waveguide which connects the 4th input/output port by the side of multiplexing which is the element of which the set A-4 of those other than the set A-1 of the optical input/output port of a light wave length multiplexing/demultiplexing circuit, A-2, and A-3, and the optical output port of the 4th uni-directional optical amplification means, The optical waveguide which connects the 5th input/output port by the side of multiplexing which is the element of which the set A-5 of those other than the set A-1 of the optical input/output port of a light wave length multiplexing/demultiplexing circuit, A-2, A-3, and A-4, and the optical input port of the 1st optical circulator, The optical waveguide which connects the 6th input/output port by the side of multiplexing which is the element of which the set A-6 of those other than the set A-1 of the optical input/output port of a light wave length multiplexing/demultiplexing circuit, A-2, A-3, A-4, and A-5, and the optical input port of the 2nd optical circulator, The optical waveguide which connects the 7th input/output port by the side of multiplexing which is the element of which the set A-7 of those other than the set A-1 of the optical input/output port of a light wave length multiplexing/demultiplexing circuit, A-2, A-3, A-4, A-5, and A-6, and the optical input port of the 3rd optical circulator, The optical waveguide which connects the 8th input/output port by the side of multiplexing which is the element of which the set A-8 of those other than the set A-1 of the optical input/output port of a light wave length multiplexing/demultiplexing circuit, A-2, A-3, A-4, A-5, A-6, and A-7, and the optical input port of the 4th optical circulator, The optical waveguide which connects the optical input port of said 1st uni-directional optical amplification means, and the optical output port of said 1st optical circulator, The optical waveguide which connects the optical input port of said 2nd uni-directional optical amplification means, and the optical output port of said 2nd optical circulator, The optical waveguide which connects the optical input port of said 3rd uni-directional optical amplification means, and the optical output port of said 3rd optical circulator, The optical waveguide

which connects the optical input port of said 4th uni-directional optical amplification means, and the optical output port of said 4th optical circulator, Switching circuit S1-i for optical cross-connects corresponding to element λ_{dai} ($i=1, 2, \dots, N$) of the set LO of a light wave length channel, The optical waveguide which connects altogether the 1st optical input/output port by the side of the spectral separation corresponding to wavelength channel λ_{dai} of the set A-1 about the wavelength multiplexing/demultiplexing of the 1st optical input port of either SP-i or optical circuit S3-i, and said light wave length multiplexing/demultiplexing circuit, respectively, The optical waveguide which connects altogether the 2nd optical input/output port by the side of the spectral separation corresponding to wavelength channel λ_{dai} of the set A-2 about the wavelength multiplexing/demultiplexing of the 2nd optical input port of either switching circuit S1-i for optical cross-connects, SP-i or optical circuit S3-i, and said light wave length multiplexing/demultiplexing circuit, respectively, The optical waveguide which connects altogether the 3rd optical input/output port by the side of the spectral separation corresponding to wavelength channel λ_{dai} of the set A-3 about the wavelength multiplexing/demultiplexing of the 3rd optical input port of either switching circuit S1-i for optical cross-connects, SP-i or optical circuit S3-i, and said light wave length multiplexing/demultiplexing circuit, respectively, The optical waveguide which connects altogether the 4th optical input/output port by the side of the spectral separation corresponding to wavelength channel λ_{dai} of the set A-4 about the wavelength multiplexing/demultiplexing of the 4th optical input port of either switching circuit S1-i for optical cross-connects, SP-i or optical circuit S3-i, and said light wave length multiplexing/demultiplexing circuit, respectively, The optical waveguide which connects altogether the 5th optical input/output port by the side of the spectral separation corresponding to wavelength channel λ_{dai} of the set A-5 about the wavelength multiplexing/demultiplexing of the 1st optical output port of either switching circuit S1-i for optical cross-connects, SP-i or optical circuit S3-i, and said light wave length multiplexing/demultiplexing circuit, respectively, The optical waveguide which connects altogether the 6th optical input/output port by the side of the spectral separation corresponding to wavelength channel λ_{dai} of the set A-6 about the wavelength multiplexing/demultiplexing of the 2nd optical output port of either switching circuit S1-i for optical cross-connects, SP-i or optical circuit S3-i, and said light wave length multiplexing/demultiplexing circuit, respectively, The optical waveguide which connects altogether the 7th optical input/output port by the side of the spectral separation corresponding to wavelength channel λ_{dai} of the set A-7 about the wavelength multiplexing/demultiplexing of the 3rd optical output port of either switching circuit S1-i for optical cross-connects, SP-i or optical circuit S3-i, and said light wave length multiplexing/demultiplexing circuit, respectively, Switching circuit S1-i for optical cross-connects, Having the optical waveguide which connects altogether the 8th optical input/output port by the side of the spectral separation corresponding to wavelength channel λ_{dai} of the set A-8 about the wavelength multiplexing/demultiplexing of the 4th optical output port of either SP-i or optical circuit S3-i, and said light wave length multiplexing/demultiplexing circuit, respectively The optical circuit for an optical pass arrangement by which it is characterized.

[Claim 6] Said switching circuit S1-j for optical cross-connects It is formed on 1 or two or more PLC substrates, and has the 1st, two 2nd optical input port and the 1st, and 2nd two optical output ports. Signal light is made to penetrate between the 1st optical input port and the 1st optical output port and between the 2nd optical input port and the 2nd optical output port. And [whether signal light is intercepted among all the optical input/output

port between the 1st optical input port and the 1st optical output port and except between the 2nd optical input port and the 2nd optical output port, and] Or signal light is made to penetrate between the 1st optical input port and the 2nd optical output port and between the 2nd optical input port and the 1st optical output port. And 2x2 cross-bar actuation optical switch circuit CS-k which can choose as arbitration whether signal light is intercepted among all the optical input/output port between the 1st optical input port and the 2nd optical output port and except between the 2nd optical input port and the 1st optical output port ($k=1$), Each is equipped with the 1st and 2nd spectral separation side [two] light input/output port and multiplexing side [one] light input/output port. Signal light is made to penetrate between the 1st spectral separation side light input/output port and the 1st multiplexing side light input/output port. And [whether signal light is intercepted among all the optical input/output port except between the 1st spectral separation side light input/output port and the 1st multiplexing side light input/output port, and] Or signal light is made to penetrate between the 2nd spectral separation side light input/output port and the 1st multiplexing side light input/output port. And the 1st thru/ or 4th four 2x1 transparency joint port selection optical switch circuit SS-i ($i=1, 2, 3, 4$) which can choose as arbitration whether signal light is intercepted among all the optical input/output port except between the 2nd spectral separation side light input/output port and the 1st multiplexing side light input/output port, The optical waveguide which connects the 1st optical input port of switching circuit S1-j for optical cross-connects, and which 1st spectral separation side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-1, The optical waveguide which connects the 2nd optical input port of switching circuit S1-j for optical cross-connects, and said 2nd spectral separation side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-1, The optical waveguide which connects the 3rd optical input port of switching circuit S1-j for optical cross-connects, and which [except said 2x1 transparency joint port selection optical switch circuit SS-1] 2nd spectral separation side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-2, The optical waveguide which connects the 4th optical input port of switching circuit S1-j for optical cross-connects, and said 1st spectral separation side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-2, The optical waveguide which connects which [except the 1st optical output port of switching circuit S1-j for optical cross-connects, said 2x1 transparency joint port selection optical switch circuit SS-1, and SS-2] 2nd spectral separation side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-3, The optical waveguide which connects the 2nd optical output port of switching circuit S1-j for optical cross-connects, and said 1st spectral separation side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-3, Which [except the 3rd optical output port of switching circuit S1-j for optical cross-connects, said 2x1 transparency joint port selection optical switch circuit SS-1, SS-2, and SS-2] 1st spectral separation side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-4 The optical waveguide which connects the optical waveguide to connect, and the 4th optical output port of switching circuit S1-j for optical cross-connects and said 2nd spectral separation side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-4, The optical waveguide which connects said 1st multiplexing side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-1, and said 1st optical input port of 2x2 cross-bar actuation optical switch circuit CS-1, The optical waveguide which connects said 1st multiplexing side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-2, and said 2nd optical input port of 2x2 cross-bar

actuation optical switch circuit CS-1, The optical waveguide which connects said 1st multiplexing side optical output port of 2x1 transparency joint port selection optical switch circuit SS-3, and said 1st optical output port of 2x2 cross-bar actuation optical switch circuit CS-1, The optical circuit for an optical pass arrangement according to claim 5 characterized by having the optical waveguide which connects said 1st multiplexing side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-4, and said 2nd optical output port of 2x2 cross-bar actuation optical switch circuit CS-1.

[Claim 7] Said switch SP-j for optical cross-connects Are created on 1 or two or more PLC substrates, and each is equipped with the 1st, two 2nd optical input port and the 1st, and 2nd two optical output ports, and makes signal light penetrate between the 1st optical input port and the 1st optical output port and between the 2nd optical input port and the 2nd optical output port. And [whether signal light is intercepted among all the optical input/output port between the 1st optical input port and the 1st optical output port and except between the 2nd optical input port and the 2nd optical output port, and] Or signal light is made to penetrate between the 1st optical input port and the 2nd optical output port and between the 2nd optical input port and the 1st optical output port. And between the 1st optical input port and the 2nd optical output port And the 1st thru/or 4th four 2x2 cross-bar actuation optical switch circuit CS-k (k= 1, 2, 3, 4) which can choose as arbitration whether signal light is intercepted among all the optical input/output port except between the 2nd optical input port and the 1st optical output port, Each is equipped with the 1st and 2nd spectral separation side [two] light input/output port and multiplexing side [one] light input/output port. Signal light is made to penetrate between the 1st spectral separation side light input/output port and the 1st multiplexing side light input/output port. And [whether signal light is intercepted among all the optical input/output port except between the 1st spectral separation side light input/output port and the 1st multiplexing side light input/output port, and] Or signal light is made to penetrate between the 2nd spectral separation side light input/output port and the 1st multiplexing side light input/output port. And the 1st thru/or 4th four 2x1 transparency joint port selection optical switch circuit SS-i (i= 1, 2, 3, 4) which can choose as arbitration whether signal light is intercepted among all the optical input/output port except between the 2nd spectral separation side light input/output port and the 1st multiplexing side light input/output port, The optical waveguide which connects the 1st optical input port of switch SP-j for optical cross-connects, and which 2nd optical input port of 2x2 cross-bar actuation optical switch circuit CS-1, The optical waveguide which connects the 2nd optical input port of switch SP-j for optical cross-connects, and said 1st optical input port of 2x2 cross-bar actuation optical switch circuit CS-1, The optical waveguide which connects the 3rd optical input port of switch SP-j for optical cross-connects, and which 1st optical input port of 2x2 cross-bar actuation optical switch circuit CS-2 except said 2x2 cross-bar actuation optical switch circuit CS-1, The optical waveguide which connects the 4th optical input port of switch SP-j for optical cross-connects, and said 2nd optical input port of 2x2 cross-bar actuation optical switch circuit CS-2, The optical waveguide which connects the 1st optical output port of switch SP-j for optical cross-connects, and which 2nd optical output port of 2x2 cross-bar actuation optical switch circuit CS-3 except 2x2 cross-bar actuation optical switch circuit CS-1 and CS-2, The optical waveguide which connects the 2nd optical output port of switch SP-j for optical cross-connects, and the 1st optical output port of 2x2 cross-bar actuation optical switch circuit CS-3, The optical waveguide which connects the 3rd optical output port of switch SP-j for optical cross-connects, and which 1st optical output port of 2x2 cross-bar actuation optical switch circuit CS-4 except 2x2 cross-bar actuation optical switch circuit CS-1, CS-2, and CS-3, The optical waveguide

which connects the 4th optical output port of switch SP-j for optical cross-connects; and the 2nd optical output port of 2x2 cross-bar actuation optical switch circuit CS-4, The optical waveguide which connects the 1st optical output port of 2x2 cross-bar actuation optical switch circuit CS-1, and which 2nd spectral separation side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-1, The optical waveguide which connects the 1st optical output port of 2x2 cross-bar actuation optical switch circuit CS-2, and said 1st spectral separation side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-1, The optical waveguide which connects the 2nd optical output port of 2x2 cross-bar actuation optical switch circuit CS-2, and which [except 2x1 transparency joint port selection optical switch circuit SS-1] 1st spectral separation side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-2, The optical waveguide which connects the 2nd optical output port of 2x2 cross-bar actuation optical switch circuit CS-1, and said 2nd spectral separation side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-2, The optical waveguide which connects the 1st optical input port of 2x2 cross-bar actuation optical switch circuit CS-3, and which [except SS-2] 2x1 transparency joint port selection optical switch circuit SS-1 and 1st [of 2x1 transparency joint port selection optical switch circuit SS-3] spectral separation side light input/output port, The optical waveguide which connects the 1st optical input port of 2x2 cross-bar actuation optical switch circuit CS-4, and the 1st spectral separation side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-3, The optical waveguide which connects the 2nd optical input port of 2x2 cross-bar actuation optical switch circuit CS-4, and which [except SS-3] 2x1 transparency joint port selection optical switch circuit SS-1, SS-2, and 2nd [of 2x1 transparency joint port selection optical switch circuit SS-4] spectral separation side light input/output port, The optical waveguide which connects the 2nd optical input port of 2x2 cross-bar actuation optical switch circuit CS-3, and the 1st spectral separation side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-4, The optical waveguide which connects the 1st multiplexing side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-1, and the 1st multiplexing side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-3, The optical circuit for an optical pass arrangement according to claim 5 characterized by having the optical waveguide which connects the 1st multiplexing side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-2, and the 1st multiplexing side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-4.

[Claim 8] Said 2x2 cross-bar actuation optical switch circuit CS-i is an optical circuit for an optical pass arrangement according to claim 6 or 7 characterized by consisting of a Mach TSUENDA mold flat-surface waveguide light TO switching circuit, a double-gate Mach TSUENDA mold flat-surface waveguide light LN switching circuit, a double-gate Mach TSUENDA mold flat-surface waveguide light LN switching circuit, or a semi-conductor light amplifier (SOA) mold 2x2 optical-switch circuit.

[Claim 9] Said 2x1 transparency joint port selection optical switch circuit SS-i The inside of four optical input/output port of a Mach TSUENDA mold flat-surface waveguide light TO switching circuit, The inside of four optical input/output port of the thing realized using any three optical input/output port, or a double-gate Mach TSUENDA mold flat-surface waveguide light TO switching circuit, What was realized using any three optical input/output port, Or the inside of the optical waveguide which connects between the optical input/output port of the four Mach TSUENDA mold flat-surface waveguide

light TO switching circuit section in the configuration of a double-gate Mach TSUENDA mold flat-surface waveguide light TO switching circuit, and these four Mach TSUENDA mold flat-surface waveguide light TO switching circuit section, The 2x1 transparency joint port selection optical switch circuit which consists of only optical waveguides which connect between the optical input/output port of the three Mach [any] TSUENDA mold flat-surface waveguide light TO switching circuit section and these three Mach TSUENDA mold flat-surface waveguide light TO switching circuit section, Or the inside of four optical input/output port of a Mach TSUENDA mold flat-surface waveguide light LN switching circuit, The inside of four optical input/output port of the thing realized using any three optical input/output port, or a double-gate Mach TSUENDA mold flat-surface waveguide light LN switching circuit, What was realized using any three optical input/output port, Or the inside of the optical waveguide which connects between the optical input/output port of the four Mach TSUENDA mold flat-surface waveguide light LN switching circuit section in the configuration of a double-gate Mach TSUENDA mold flat-surface waveguide light LN switching circuit, and these four Mach TSUENDA mold flat-surface waveguide light LN switching circuit section, Consisting of 2x1 transparency joint port selection optical switch circuits which consist of only optical waveguides which connect between the optical input/output port of the three Mach [any] TSUENDA mold flat-surface waveguide light LN switching circuit section and these three Mach TSUENDA mold flat-surface waveguide light LN switching circuit section The optical circuit for an optical pass arrangement according to claim 6 or 7 by which it is characterized.

[Claim 10] Said switching circuit S1-j for optical cross-connects All configuration optical circuits are created on one PLC substrate flat surface, and it sees from a substrate top face. Clockwise The 2nd optical output port of switching circuit S1-j for optical cross-connects, The 1st optical output port, the 3rd optical output port, the 4th optical output port, the 4th optical input port, It is arranged so that each optical input and output port may adjoin each other in order of the 3rd optical input port, the 1st optical input port, and the 2nd optical input port. The optical input/output port of 2x2 cross-bar actuation optical switch circuit CS-k ($k=1$) sees from a substrate top face. Clockwise The 2nd optical input port, the 1st optical input port, the 1st optical output port, Are arranged so that each other may be adjoined in order of the 2nd optical output port, and the optical input/output port of four 2x1 transparency joint port selection optical switch circuit SS-i ($i=1, 2, 3, 4$) sees from a substrate top face. Clockwise The 1st spectral separation side light input/output port, the 2nd spectral separation side light input/output port, By being arranged so that each other may be adjoined in order of the 1st multiplexing side light input/output port, and giving moderately spacing of each 2x2 cross-bar actuation optical switch circuit and a 2x1 transparency joint port selection optical switch circuit further The optical circuit for an optical pass arrangement according to claim 6 characterized by being the arrangement which neither of the optical waveguides which connects between the optical input port of each 2x2 cross-bar actuation optical switch circuit and a 2x1 transparency joint port selection optical switch circuit and an optical output port intersects.

[Claim 11] As for switch SP-j for optical cross-connects, all configuration optical circuits are created on one PLC substrate flat surface. It sees from a substrate top face. Clockwise The 2nd optical output port of switch SP-j for optical cross-connects, The 1st optical output port, the 3rd optical output port, the 4th optical output port, the 4th optical input port, It is arranged so that each optical input and output port may adjoin each other in order of the 3rd optical input port, the 1st optical input port, and the 2nd optical input port. The optical input/output port of four 2x2 cross-bar actuation optical switch circuit CS-k

($k=1, 2, 3, 4$) seen from a substrate top face. Clockwise The 2nd optical input port, the 1st optical input port, the 1st optical output port, Are arranged so that each other may be adjoined in order of the 2nd optical output port, and the optical input/output port of four 2x1 transparency joint port selection optical switch circuit SS-i ($i=1, 2, 3, 4$) seen from a substrate top face. Clockwise The 1st spectral separation side light input/output port, the 2nd spectral separation side light input/output port, By being arranged so that each other may be adjoined in order of the 1st multiplexing side light input/output port, and giving moderately spacing of each 2x2 cross-bar actuation optical switch circuit further In which optical waveguide which connects between the optical input port of each 2x2 cross-bar actuation optical switch circuit, and an optical output port Between the 2nd optical output port of 2x2 cross-bar actuation optical switch circuit CS-1, and the 2nd spectral separation side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-2, The optical waveguide which connects between the 1st optical output port of 2x2 cross-bar actuation optical switch circuit CS-2, and the 1st spectral separation side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-1, respectively, Between the 2nd optical input port of 2x2 cross-bar actuation optical switch circuit CS-3, and the 1st spectral separation side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-4, and the 1st optical input port of 2x2 cross-bar actuation optical switch circuit CS-4 2 sets with the optical waveguide which connects between the 2nd spectral separation side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-3, respectively, respectively Every one place, The optical circuit for an optical pass arrangement according to claim 7 characterized by being arrangement without the crossover of the optical waveguide which only a total of two places cross and connects between the other optical input port and an optical output port.

[Claim 12] Said light wave length multiplexing/demultiplexing circuit is an optical circuit for an optical pass arrangement according to claim 5 characterized by being an array waveguide mold flat-surface optical circuit (AWG).

[Claim 13] One array waveguide flat-surface optical circuit WM-1 with all the waveguides for optical I/O that do not cross mutually [form the set A-1 about wavelength multiplexing/demultiplexing, A-2, A-3, and A-4, and], One array waveguide flat-surface optical circuit WM-2 with all the waveguides for optical I/O that do not cross mutually [form the set A-5 about wavelength multiplexing/demultiplexing, A-6, A-7, and A-8, and], Switching circuit S1-j for 4 input 4 output optical cross-connects and SP-j by which it is arranged according to an individual respectively corresponding to each wavelength channel, and those either is arranged for every wavelength channel, and optical circuit S3-j, Optical input/output port and switching circuit S1-j for 4 input 4 output optical cross-connects of said array waveguide flat-surface optical circuit WM-1 and WM-2, In the light wave length multiplexing/demultiplexing circuit and the switching circuit section for optical cross-connects which consist of optical waveguides which connect the ports corresponding to each of the optical input port of SP-j and optical circuit S3-j ($j=1, 2, \dots, N$), and an optical output port The optical input/output port corresponding to wavelength channel λ_{dai} of arbitration by which [a clockwise rotation or / counter clockwise] the surroundings by the optical I/O waveguide by the side of spectral separation of said the set of array waveguide flat-surface optical circuit WM-1 of each The 2nd, the 1st, the 3rd, the 4th spectral separation side light input/output port It has stood in a line in order of (A-I/O-d-2-i, A-I/O-d-1-i, A-I/O-d-3-i, A-I/O-d-4-i). and between the optical input/output port located in a line with such sequence The ** into which the optical input/output port by the side of the spectral separation from which the optical input/output port and the

corresponding wavelength channel by the side of all other multiplexing differ does not enter, Optical input/output port has accomplished the ensemble respectively in location for every corresponding wavelength channel. The optical input/output port corresponding to wavelength channel λ_{dai} of arbitration sets to said array waveguide flat-surface optical circuit WM-1 by the optical I/O waveguide by the side of spectral separation of said the set of array waveguide flat-surface optical circuit WM-2 of each. The surroundings from which optical input/output port serves as sequence of the 2nd, 1st, 3rd, and 4th spectral separation side light input/output port (A-I/O-d-2-i, A-I/O-d-1-i, A-I/O-d-3-i, A-I/O-d-4-i) to the circumference of reverse The 6th, the 5th, the 7th, the 8th spectral separation side light input/output port It has stood in a line in order of (A-I/O-d-6-i, A-I/O-d-5-i, A-I/O-d-7-i, A-I/O-d-8-i). and between the optical input/output port located in a line with such sequence The ** into which the optical input/output port by the side of the spectral separation from which the optical input/output port and the corresponding wavelength channel by the side of all other multiplexing differ does not enter, Optical input/output port has accomplished the ensemble respectively in location for every corresponding wavelength channel. Furthermore, it is related with the wavelength channel to which the ensembles of the optical input/output port for every wavelength channel by the side of spectral separation correspond. The sequence of the list about the wavelength channel to which the ensembles of the optical input/output port for every wavelength channel by the side of the sequence of ***** and said spectral separation of array waveguide flat-surface optical circuit WM-1 correspond is the sequence mutually same at the circumference of reverse. Furthermore, each switching circuit S1-j for 4 input 4 output optical cross-connects, SP-j, And it is related with the wavelength channel to which the ensembles of the optical output port of optical circuit S3-j ($j=1, 2, \dots, N$) correspond. The sequence of the list about the wavelength channel to which the ensembles of the optical input/output port for every wavelength channel by the side of the sequence of ***** and said spectral separation of array waveguide flat-surface optical circuit WM-1 correspond is the same sequence by the mutually same surroundings. And each switching circuit S1-j for 4 input 4 output optical cross-connects, SP-j, And it is related with the wavelength channel to which the ensembles of the optical output port of optical circuit S3-j ($j=1, 2, \dots, N$) correspond. When the sequence of the list about the wavelength channel to which the ensembles of the optical input/output port for every wavelength channel by the side of the sequence of ***** and said spectral separation of array waveguide flat-surface optical circuit WM-1 correspond is the sequence mutually same at the circumference of reverse On the same flat surface, array waveguide flat-surface optical circuit WM-1, WM-2 and switching circuit S1 for 4 input 4 output optical cross-connects-j, It is the arrangement and the configuration of a circuit in which one does not have what crosses mutually by the optical waveguides which connect SP-j and optical circuit S3-j ($j=1, 2, \dots, N$). Array waveguide flat-surface optical circuit WM-1, WM-2 and switching circuit S1-j for 4 input 4 output optical cross-connects, SP-j, and optical circuit S3-j ($j=1, 2, \dots, N$), Array waveguide flat-surface optical circuit WM-1, WM-2, and switching circuit S1-j for 4 input 4 output optical cross-connects, [whether the optical waveguide which connects between SP-j and optical circuit S3-j ($j=1, 2, \dots, N$), respectively is created on the same flat-surface substrate, and] Or the optical circuit for an optical pass arrangement according to claim 5 characterized by combining each optical input/output port in the form which compares and carries out the flat-surface circuit board of the light wave length multiplexing/demultiplexing section and the flat-surface circuit board of the switching circuit for optical cross-connects by which the individual exception was created, and forming one plane optical circuit.

[Claim 14] In said optical circulator, the light inputted into optical input port The light which was outputted from optical input/output port and inputted from optical input/output port The light which is outputted from an optical output port, is inputted from optical input/output port and outputted from optical input port The light which is fully oppressed, is inputted from an optical output port, and is outputted from optical input/output port is an optical circuit for an optical pass arrangement according to claim 5 characterized by fully being oppressed, not being concerned with the sense of I/O of light between optical input port and an optical output port, but fully oppressing light.

[Translation done.]

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2. **** shows the word which can not be translated.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the optical circuit for an optical pass arrangement effective in the optical circuit for a communication link.

[0002]

[Description of the Prior Art] The example of a configuration of the conventional optical cross-connect circuit known widely and an optical ad drop circuit is shown in drawing 9 and drawing 10, respectively. In both drawings 1-1, 1-2, 1-3, and 1-4 the light wave length multiplexing/demultiplexing section 2-1, 2-2, 2-3, 2-4, and 3-j ($j = 1, 2, \dots, n$) for a light amplifier 1-1, 1-2, 1-3, 1-4, 2-1, 2-2, 2-3, and 2-4 2 input 2 output cross-bar actuation optical switch circuit 3-j, Extraneous light input port, 0-2, 0-4, and 0-4-1 - 0-4-n of 0-1, 0-3, and 0-3-1 - 0-3-n are external optical output ports.

[0003] In drawing 9 and drawing 10, a light amplifier 1-1, 1-2, 1-3, and 1-4 are prepared for compensation of loss of an optical transmission line, and compensation of loss of the part except the light amplifier of an optical cross-connect circuit and the optical ad drop circuit itself. The configuration of each light amplifier 1-1, 1-2, 1-3, and 1-4 Since the reflective spot of the lightwave signal of a connector joint part etc. exists on a general transmission line In order to intercept the reflected light from these reflective spots, to be stabilized and to perform optical amplification, as shown in drawing 11, the optical isolator 1-i-2-1 which restricts propagation of signal light only in the desired direction of optical transmission, and 1-i-2-2 are prepared before and after the optical amplification section 1-i-1. For this reason, also when carrying out optical amplification of the wavelength multiplexing lightwave signal, the whole of that propagation direction is restricted in the same direction.

[0004] Moreover, generally as the optical amplification section which is the component of a light amplifier 1-1, 1-2, 1-3, and 1-4, the optical amplification section (drawing 12 d) of the rare earth addition optical fiber of the bidirectional excitation (drawing 12 a) by the semiconductor laser for excitation, front excitation (drawing 12 b), and back excitation (drawing 12 c) or a semi-conductor mold is used.

[0005] In order that quartz system glass may usually expand a magnification wavelength band, Zr system fluoride glass and Telluride system glass are used for the host of a rare earth addition optical fiber. Moreover, as addition rare earth, Pr^{3+} is used for $1.5 \times 10^{-6}\text{m}$ bands for $1.3 \times 10^{-6}\text{m}$ bands (the 1995 autumn SHINGAKUKAI collected works C216 besides Yamada, A.Mori, et al.OFC97, PDP1 reference).

[0006] In addition, for a rare earth addition fiber, 5-1, and 5-2, as for an optical isolator, 7-1, and 7-2, in drawing 12, the laser for excitation, 6-1, and 6-2 are [4 / a wavelength multiplexing/demultiplexing coupler and 8] flat-surface mold waveguide substrates.

[0007] First, actuation of the optical cross-connect circuit shown in drawing 9 is explained. In the optical cross-connect circuit shown in drawing 9, optical amplification of the external input port 0-1 and the wavelength multiple-signal light inputted from 0-3 is carried out by the light amplifier 1-1 and 1-3, respectively, and it is separated spectrally for every signal light of each wavelength channel by the light wave length multiplexing/demultiplexing section 2-1 and 2-3. The signal light separated spectrally for every wavelength channel in the light wave length multiplexing/demultiplexing section is inputted into a mutually different 2 input 2 output cross-bar actuation optical switch circuit 3-1 for every pair of the signal light corresponding to the respectively same wavelength channel - 3-n, and change selection of the output port of a cross bar is performed, and it is outputted according to an individual, respectively.

[0008] It is multiplexed by the light wave length multiplexing/demultiplexing section 2-2 and 2-4 for every meeting of two signal light which duplication does not produce in a wavelength channel, respectively, and after optical amplification of this outputted signal light is carried out by the latter light amplifier 1-2 and 1-4, it is outputted from the external output port 0-2 and 0-4.

[0009] Recombination of the indemnity of an optical transmission line and the wavelength channel of two wavelength multiple-signal light, i.e., an optical cross-connect, is realized by the actuation in the optical cross-connect circuit mentioned above.
 [0010] Next, actuation of the optical ad drop circuit shown in drawing 10 is explained. In the optical ad drop circuit shown in drawing 10, optical amplification of the wavelength multiple-signal light inputted from the external input port 0-1 is carried out with a light amplifier 1-1, and it is separated spectrally for every signal light of each wavelength channel in the light wave length multiplexing/demultiplexing section 2-1. The ad (ADD) input signal light inputted from the external input port 0-3-1 prepared for every signal light separated spectrally for every wavelength channel in the light wave length multiplexing/demultiplexing section and wavelength channel - 0-3-n It is inputted into a mutually different 2 input 2 output cross-bar actuation optical switch circuit 3-1 for every pair of the signal light corresponding to the respectively same wavelength channel - 3-n, and is outputted by performing change selection of the output port of a cross bar according to an individual, respectively.

[0011] One side is multiplexed in the light wave length multiplexing/demultiplexing section 2-2 for every meeting of two signal light which duplication does not produce in a wavelength channel, respectively, and this outputted signal light is outputted as a drop (DROP) output signal light from the external output port 0-4-1 - 0-4-n which were able to prepare another side for every wavelength channel. The wavelength multiple-signal light it was multiplexed [light] in the light wave length multiplexing/demultiplexing section 2-2 is outputted from the external output port 0-2, after optical amplification is carried out with the latter light amplifier 1-2.

[0012] The ad drop of the signal light for every wavelength channel of the indemnity of an optical transmission line and wavelength multiple-signal light is realized by actuation of

the optical ad drop circuit mentioned above.

[0013]

[Problem(s) to be Solved by the Invention] since the uni directional light amplifier be being use for the conventional optical cross-connect circuit and the optical ad drop circuit which be mentioned above in order it compensate loss of an optical transmission line and the optical circuit itself , they be that it be fix in the same direction which be altogether decided beforehand about the propagation direction of wavelength multiple signal light and exist , and have the problem that where of a function will be restrict only to a change of two conditions of the path of a cross bar mold as a result .

[0014] The place which this invention was made in view of the above, and is made into the object The inside of an optical fiber is spread in the propagation direction of arbitration about going up and the direction of going down for every wavelength channel. And optical amplification is carried out, responding the wavelength multiple-signal light belonging to two streams accompanying a dynamic change of changing each propagation direction to up Rika going down or lower Rika going up if needed for every wavelength channel each time, and securing the isolation to the propagation direction of signal light. And while realizing eight kinds of optical propagation magnification conditions shown in drawing 6 realized by performing an optical cross-connect for every wavelength channel Choose input/output port as arbitration in the range which does not overlap to four signal light input/output port, respectively for every wavelength channel, and signal light is made to output and input. It is in offering the optical circuit for an optical pass arrangement which can attain implementation of 12 kinds of optical propagation magnification conditions which show two signal light streams in drawing 7 which is all the combination that carries out propagation magnification.

[0015]

[Means for Solving the Problem] In order to attain the above-mentioned object, this invention according to claim 1 Four optical circulators which are the optical circuits for an optical pass arrangement which have at least four extraneous light input/output port, and have said extraneous light input/output port, the input/output port connected, input port, and an output port, respectively, Four uni-directional optical amplification means to input the signal light from the output port of these optical circulators, respectively, and to amplify it, Let it be a summary to input the signal light outputted from these four uni-directional optical amplification means, respectively, and to have the optical control means which controls the output to the input port of said optical circulator of this signal light.

[0016] Moreover, this invention according to claim 2 makes it a summary for an optical control means to consist of two light wave length multiplexing/demultiplexing circuits and two or more optical cross-connect ADODOROPPU switches in this invention according to claim 1.

[0017] This invention according to claim 3 is set to this invention according to claim 2. Moreover, said optical cross-connect ADODOROPPU switch The transparency joint port selection optical switch which chooses two or more inputted lightwave signals suitably, and outputs them from said one near light wave length multiplexing/demultiplexing circuit, The output crossbar actuation optical switch which inputs the lightwave signal from this transparency joint port selection optical switch, and changes and outputs an output destination change port suitably, Let it be a summary to be constituted by the transparency joint port selection optical switch which chooses suitably the output destination change port where the lightwave signal from this output crossbar actuation optical switch is connected to said near light wave length multiplexing/demultiplexing circuit of another

side, and outputs it.

[0018] This invention according to claim 4 is set to this invention according to claim 2. Moreover, said optical cross-connect ADODOROPPU switch The output crossbar actuation optical switch which changes and outputs two or more inputted lightwave signals for an output destination change port suitably from said one near light wave length multiplexing/demultiplexing circuit, The transparency joint port selection optical switch which chooses suitably two or more lightwave signals inputted from this output crossbar actuation optical switch, and outputs them, The transparency joint port selection optical switch which chooses an output destination change port and outputs suitably the lightwave signal inputted from this transparency joint port selection optical switch, Let it be a summary to be constituted by the output crossbar actuation optical switch which chooses suitably the output destination change port where the lightwave signal from this transparency joint port selection optical switch is connected to said near light wave length multiplexing/demultiplexing circuit of another side, and outputs it.

[0019] The 1st thru/or the 4th optical circulator in which, as for this invention according to claim 5, each has the optical input/output port to which each of the 1st thru/or 4th extraneous light input/output port is connected, optical input port, and an optical output port, The 1st four optical input/output port to which said the 1st thru/or each optical input port of the 4th optical circulator is connected corresponding to 1 to 1, and -- this -- with 1 which has the 2nd four different optical input/output port from the 1st four optical input/output port, or two or more light wave length multiplexing/demultiplexing circuits Among the 2nd four optical input/output port of said light wave length multiplexing/demultiplexing circuit corresponding to 1 to 1 in the 1st thru/or each optical output port of the 4th optical circulator [with each optical output port of said the 1st thru/or 4th optical circulator, and the 2nd four optical input/output port of said light wave length multiplexing/demultiplexing circuit] Connect and it has 1st thru/or 4th four uni-directional optical amplification means to amplify and output the lightwave signal spread in the direction which goes to the 2nd four optical input/output port of said light wave length multiplexing/demultiplexing circuit from the 1st thru/or each optical output port of the 4th optical circulator. It has the 1st thru/or 4th optical input port and 1st thru/or 4th optical output port. Signal light is made to penetrate between the 1st optical input port and the 2nd optical output port and between the 3rd optical input port and the 4th optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 1st optical input port and the 2nd optical output port and except between the 3rd optical input port and the 4th optical output port, and] Or signal light is made to penetrate between the 1st optical input port and the 2nd optical output port and between the 4th optical input port and the 3rd optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 1st optical input port and the 2nd optical output port and except between the 4th optical input port and the 3rd optical output port, and] Or signal light is made to penetrate between the 1st optical input port and the 4th optical output port and between the 3rd optical input port and the 2nd optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 1st optical input port and the 4th optical output port and except between the 3rd optical input port and the 2nd optical output port, and] Or signal light is made to penetrate between the 1st optical input port and the 3rd optical output port and between the 4th optical input port and the 2nd optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 1st optical input port and the 3rd optical output port and except between the 4th optical input port and the 2nd optical output port, and] Or

signal light is made to penetrate between the 2nd optical input port and the 1st optical output port and between the 3rd optical input port and the 4th optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 2nd optical input port and the 1st optical output port and except between the 3rd optical input port and the 4th optical output port, and] Or signal light is made to penetrate between the 2nd optical input port and the 1st optical output port and between the 4th optical input port and the 3rd optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 2nd optical input port and the 1st optical output port and except between the 4th optical input port and the 3rd optical output port, and] Or signal light is made to penetrate between the 2nd optical input port and the 3rd optical output port and between the 4th optical input port and the 1st optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 2nd optical input port and the 3rd optical output port and except between the 4th optical input port and the 1st optical output port, and] Or signal light is made to penetrate between the 2nd optical input port and the 4th optical output port and between the 3rd optical input port and the 1st optical output port. And between the 2nd optical input port and the 4th optical output port Whether signal light is intercepted among all the optical input port and optical output ports except between the 3rd optical input port and the 1st optical output port And switching circuit S1-j for 4 input 4 output optical cross-connects selectable to arbitration ($j = 1, 2, \dots, N$), Or it has the 1st thru/or 4th optical input port and the 1st thru/or the 4th optical output port. Signal light is made to penetrate between the 1st optical input port and the 2nd optical output port and between the 3rd optical input port and the 4th optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 1st optical input port and the 2nd optical output port and except between the 3rd optical input port and the 4th optical output port, and] Or signal light is made to penetrate between the 1st optical input port and the 2nd optical output port and between the 4th optical input port and the 3rd optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 1st optical input port and the 2nd optical output port and except between the 4th optical input port and the 3rd optical output port, and] Or signal light is made to penetrate between the 1st optical input port and the 4th optical output port and between the 3rd optical input port and the 2nd optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 1st optical input port and the 4th optical output port and except between the 3rd optical input port and the 2nd optical output port, and] Or signal light is made to penetrate between the 1st optical input port and the 3rd optical output port and between the 4th optical input port and the 2nd optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 1st optical input port and the 3rd optical output port and except between the 4th optical input port and the 2nd optical output port, and] Or signal light is made to penetrate between the 2nd optical input port and the 1st optical output port and between the 3rd optical input port and the 4th optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 2nd optical input port and the 1st optical output port and except between the 3rd optical input port and the 4th optical output port, and] Or signal light is made to penetrate between the 2nd optical input port and the 1st optical output port and between the 4th optical input port and the 3rd optical output port. And all optical input port between the 2nd optical input port and the 1st optical output port and except between the 4th optical input port and the 3rd optical output port Intercept signal light between optical output

ports, or signal light is made to penetrate between the 2nd optical input port and the 3rd optical output port and between the 4th optical input port and the 1st optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 2nd optical input port and the 3rd optical output port and except between the 4th optical input port and the 1st optical output port, and] Or signal light is made to penetrate between the 2nd optical input port and the 4th optical output port and between the 3rd optical input port and the 1st optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 2nd optical input port and the 4th optical output port and except between the 3rd optical input port and the 1st optical output port, and] Or signal light is made to penetrate between the 1st optical input port and the 3rd optical output port and between the 2nd optical input port and the 4th optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 1st optical input port and the 3rd optical output port and except between the 2nd optical input port and the 4th optical output port, and] Or signal light is made to penetrate between the 1st optical input port and the 4th optical output port and between the 2nd optical input port and the 3rd optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 1st optical input port and the 4th optical output port and except between the 2nd optical input port and the 3rd optical output port, and] Or signal light is made to penetrate between the 3rd optical input port and the 1st optical output port and between the 4th optical input port and the 2nd optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 3rd optical input port and the 1st optical output port and except between the 4th optical input port and the 2nd optical output port, and] Or signal light is made to penetrate between the 4th optical input port and the 1st optical output port and between the 3rd optical input port and the 2nd optical output port. And between the 4th optical input port and the 1st optical output port Whether signal light is intercepted among all the optical input port and optical output ports except between the 3rd optical input port and the 2nd optical output port And switch SP-j for 4 input 4 output optical cross-connects selectable to arbitration ($j = 1, 2, \dots, N$), Or it has the 1st thru/or 4th optical input port and 1st thru/or 4th optical output port. Optical waveguide between the 1st optical input port and the 2nd optical output port and between the 3rd optical input port and the 4th optical output port An epilogue, Carry out termination of all the other optical input port and optical output ports, or optical waveguide between the 1st optical input port and the 2nd optical output port and between the 4th optical input port and the 3rd optical output port An epilogue, Carry out termination of all the other optical input port and optical output ports, or optical waveguide between the 1st optical input port and the 4th optical output port and between the 3rd optical input port and the 2nd optical output port An epilogue, Carry out termination of all the other optical input port and optical output ports, or optical waveguide between the 1st optical input port and the 3rd optical output port and between the 4th optical input port and the 2nd optical output port An epilogue, Carry out termination of all the other optical input port and optical output ports, or optical waveguide between the 2nd optical input port and the 1st optical output port and between the 3rd optical input port and the 4th optical output port An epilogue, Carry out termination of all the other optical input port and optical output ports, or optical waveguide between the 2nd optical input port and the 1st optical output port and between the 4th optical input port and the 3rd optical output port An epilogue, Carry out termination of all the other optical input port and optical output ports, or optical waveguide between the 2nd optical input port and the 3rd optical output port and between

the 4th optical input port and the 1st optical output port An epilogue, Carry out termination of all the other optical input port and optical output ports, or optical waveguide between the 2nd optical input port and the 4th optical output port and between the 3rd optical input port and the 1st optical output port An epilogue, Carry out termination of all the other optical input port and optical output ports, or optical waveguide between the 1st optical input port and the 3rd optical output port and between the 2nd optical input port and the 4th optical output port An epilogue, Carry out termination of all the other optical input port and optical output ports, or optical waveguide between the 1st optical input port and the 4th optical output port and between the 2nd optical input port and the 3rd optical output port An epilogue, Carry out termination of all the other optical input port and optical output ports, or optical waveguide between the 3rd optical input port and the 4th optical output port and between the 4th optical input port and the 2nd optical output port An epilogue, Carry out termination of all the other optical input port and optical output ports, or optical waveguide between the 4th optical input port and the 1st optical output port and between the 3rd optical input port and the 2nd optical output port An epilogue, It corresponds to the light wave length channel whose either of one 4 input 4 output optical circuit S3-j ($j = 1, 2, \dots, N$) of whether termination of all the other optical input port and optical output ports is carried out is the element of the set LO of a light wave length channel separately. It is arranged, respectively. Such switching circuit S1-j for a total of N 4 input 4 output optical cross-connects, SP-j Or it is the optical circuit for an optical pass arrangement where it comes to connect two or more optical input/output port of said light wave long multiplexing/demultiplexing circuit corresponding to 1 to 1 with each of all the optical input port of 4 input 4 output optical circuit S3-j and optical output ports, these optical input port, and an optical output port, respectively. The optical input/output port of said light wave length multiplexing/demultiplexing circuit is the set about the light wave length multiplexing/demultiplexing to set LO[of a light wave length channel] = $\{\lambda_{bdaj}\}$ ($i = 1, 2, \dots, N$). And eight relatively prime sets A-1, A-2, A-3, A-4, A-5, A-6, A-7, and A-8 are formed. Except set A-1 of the optical input/output port of the optical waveguide which connects the 1st input/output port by the side of multiplexing which is the element of which the set A-1 of the optical input/output port of a light wave length multiplexing/demultiplexing circuit, and the optical output port of the 1st uni-directional optical amplification means, and a light wave length multiplexing/demultiplexing circuit The optical waveguide which connects the 2nd input/output port by the side of multiplexing which is the element of the set A-2 of *****, and the optical output port of the 2nd uni-directional optical amplification means, The optical waveguide which connects the 3rd input/output port by the side of multiplexing which is the element of the set A-1 of the optical input/output port of a light wave length multiplexing/demultiplexing circuit, and which the set A-3 of those other than A-2, and the optical output port of the 3rd uni-directional optical amplification means, The optical waveguide which connects the 4th input/output port by the side of multiplexing which is the element of which the set A-4 of those other than the set A-1 of the optical input/output port of a light wave length multiplexing/demultiplexing circuit, A-2, and A-3, and the optical output port of the 4th uni-directional optical amplification means, The optical waveguide which connects the 5th input/output port by the side of multiplexing which is the element of which the set A-5 of those other than the set A-1 of the optical input/output port of a light wave length multiplexing/demultiplexing circuit, A-2, A-3, and A-4, and the optical input port of the 1st optical circulator, The optical waveguide which connects the 6th input/output port by the side of multiplexing which is the element of which the set A-6 of those other than the

set A-1 of the optical input/output port of a light wave length multiplexing/demultiplexing circuit, A-2, A-3, A-4, and A-5, and the optical input port of the 2nd optical circulator, The optical waveguide which connects the 7th input/output port by the side of multiplexing which is the element of which the set A-7 of those other than the set A-1 of the optical input/output port of a light wave length multiplexing/demultiplexing circuit, A-2, A-3, A-4, A-5, and A-6, and the optical input port of the 3rd optical circulator, The optical waveguide which connects the 8th input/output port by the side of multiplexing which is the element of which the set A-8 of those other than the set A-1 of the optical input/output port of a light wave length multiplexing/demultiplexing circuit, A-2, A-3, A-4, A-5, A-6, and A-7, and the optical input port of the 4th optical circulator, The optical waveguide which connects the optical input port of said 1st uni-directional optical amplification means, and the optical output port of said 1st optical circulator, The optical waveguide which connects the optical input port of said 2nd uni-directional optical amplification means, and the optical output port of said 2nd optical circulator, The optical waveguide which connects the optical input port of said 3rd uni-directional optical amplification means, and the optical output port of said 3rd optical circulator, The optical waveguide which connects the optical input port of said 4th uni-directional optical amplification means, and the optical output port of said 4th optical circulator, Switching circuit S1-i for optical cross-connects corresponding to element λ_{dai} ($i = 1, 2, \dots, N$) of the set LO of a light wave length channel, The optical waveguide which connects altogether the 1st optical input/output port by the side of the spectral separation corresponding to wavelength channel λ_{dai} of the set A-1 about the wavelength multiplexing/demultiplexing of the 1st optical input port of either SP-i or optical circuit S3-i, and said light wave length multiplexing/demultiplexing circuit, respectively, The optical waveguide which connects altogether the 2nd optical input/output port by the side of the spectral separation corresponding to wavelength channel λ_{dai} of the set A-2 about the wavelength multiplexing/demultiplexing of the 2nd optical input port of either switching circuit S1-i for optical cross-connects, SP-i or optical circuit S3-i, and said light wave length multiplexing/demultiplexing circuit, respectively, The optical waveguide which connects altogether the 3rd optical input/output port by the side of the spectral separation corresponding to wavelength channel λ_{dai} of the set A-3 about the wavelength multiplexing/demultiplexing of the 3rd optical input port of either switching circuit S1-i for optical cross-connects, SP-i or optical circuit S3-i, and said light wave length multiplexing/demultiplexing circuit, respectively, The optical waveguide which connects altogether the 4th optical input/output port by the side of the spectral separation corresponding to wavelength channel λ_{dai} of the set A-4 about the wavelength multiplexing/demultiplexing of the 4th optical input port of either switching circuit S1-i for optical cross-connects, SP-i or optical circuit S3-i, and said light wave length multiplexing/demultiplexing circuit, respectively, The optical waveguide which connects altogether the 5th optical input/output port by the side of the spectral separation corresponding to wavelength channel λ_{dai} of the set A-5 about the wavelength multiplexing/demultiplexing of the 1st optical output port of either switching circuit S1-i for optical cross-connects, SP-i or optical circuit S3-i, and said light wave length multiplexing/demultiplexing circuit, respectively, The optical waveguide which connects altogether the 6th optical input/output port by the side of the spectral separation corresponding to wavelength channel λ_{dai} of the set A-6 about the wavelength multiplexing/demultiplexing of the 2nd optical output port of either switching circuit S1-i for optical cross-connects, SP-i or optical circuit S3-i, and said light wave length multiplexing/demultiplexing circuit, respectively, The optical waveguide which connects

altogether the 7th optical input/output port by the side of the spectral separation corresponding to wavelength channel λ_{dai} of the set A-7 about the wavelength multiplexing/demultiplexing of the 3rd optical output port of either switching circuit S1-i for optical cross-connects, SP-i or optical circuit S3-i, and said light wave length multiplexing/demultiplexing circuit, respectively, Switching circuit S1-j for optical cross-connects, Let it be a summary to have the optical waveguide which connects altogether the 8th optical input/output port by the side of the spectral separation corresponding to wavelength channel λ_{dai} of the set A-8 about the wavelength multiplexing/demultiplexing of the 4th optical output port of either SP-i or optical circuit S3-i, and said light wave length multiplexing/demultiplexing circuit, respectively.

[0020] The 1st thru/or the 4th optical circulator by which each optical input port was connected to extraneous light input/output port I/O -1, and 2, 3 and 4, respectively if it was in this invention according to claim 5, It has four uni-directional optical amplification means, 1 or two or more light wave length multiplexing/demultiplexing circuits and the 1st thru/or the 4th, and 12 kinds of optical propagation magnification conditions shown in extraneous light input/output port I/O -1, eight kinds of optical propagation magnification conditions shown in drawing 7 between 2, 3, and 4, and drawing 8 can be realized.

[0021] Moreover, this invention of this invention according to claim 6 is set to this invention according to claim 5. Said switching circuit S1-j for optical cross-connects is formed on 1 or two or more PLC substrates. It has the 1st, two 2nd optical input port and the 1st, and 2nd two optical output ports. Signal light is made to penetrate between the 1st optical input port and the 1st optical output port and between the 2nd optical input port and the 2nd optical output port. And [whether signal light is intercepted among all the optical input/output port between the 1st optical input port and the 1st optical output port and except between the 2nd optical input port and the 2nd optical output port, and] Or signal light is made to penetrate between the 1st optical input port and the 2nd optical output port and between the 2nd optical input port and the 1st optical output port. And 2x2 cross-bar actuation optical switch circuit CS-k which can choose as arbitration whether signal light is intercepted among all the optical input/output port between the 1st optical input port and the 2nd optical output port and except between the 2nd optical input port and the 1st optical output port ($k=1$), Each is equipped with the 1st and 2nd spectral separation side [two] light input/output port and multiplexing side [one] light input/output port. Signal light is made to penetrate between the 1st spectral separation side light input/output port and the 1st multiplexing side light input/output port. And [whether signal light is intercepted among all the optical input/output port except between the 1st spectral separation side light input/output port and the 1st multiplexing side light input/output port, and] Or signal light is made to penetrate between the 2nd spectral separation side light input/output port and the 1st multiplexing side light input/output port. And the 1st thru/or 4th four 2x1 transparency joint port selection optical switch circuit SS-i ($i=1, 2, 3, 4$) which can choose as arbitration whether signal light is intercepted among all the optical input/output port except between the 2nd spectral separation side light input/output port and the 1st multiplexing side light input/output port, The optical waveguide which connects the 1st optical input port of switching circuit S1-j for optical cross-connects, and which 1st spectral separation side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-1, The optical waveguide which connects the 2nd optical input port of switching circuit S1-j for optical cross-connects, and said 2nd spectral separation side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-1, The optical waveguide which connects the 3rd optical input port of switching circuit S1-j for optical cross-connects, and which [except

said 2x1 transparency joint port selection optical switch circuit SS-1] 2nd spectral separation side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-2, The optical waveguide which connects the 4th optical input port of switching circuit S1-j for optical cross-connects, and said 1st spectral separation side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-2, The optical waveguide which connects which [except the 1st optical output port of switching circuit S1-j for optical cross-connects, said 2x1 transparency joint port selection optical switch circuit SS-1, and SS-2] 2nd spectral separation side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-3, The optical waveguide which connects the 2nd optical output port of switching circuit S1-j for optical cross-connects, and said 1st spectral separation side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-3, Which [except the 3rd optical output port of switching circuit S1-j for optical cross-connects, said 2x1 transparency joint port selection optical switch circuit SS-1, SS-2, and SS-2] 1st spectral separation side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-4 The optical waveguide which connects the optical waveguide to connect, and the 4th optical output port of switching circuit S1-j for optical cross-connects and said 2nd spectral separation side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-4, The optical waveguide which connects said 1st multiplexing side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-1, and said 1st optical input/output port of 2x2 cross-bar actuation optical switch circuit CS-1, The optical waveguide which connects said 1st multiplexing side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-2, and said 2nd optical input port of 2x2 cross-bar actuation optical switch circuit CS-1, The optical waveguide which connects said 1st multiplexing side optical output port of 2x1 transparency joint port selection optical switch circuit SS-3, and said 1st optical output port of 2x2 cross-bar actuation optical switch circuit CS-1, Let it be a summary to have the optical waveguide which connects said 1st multiplexing side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-4, and said 2nd optical output port of 2x2 cross-bar actuation optical switch circuit CS-1.

[0022] If it is in this invention according to claim 6, in switching circuit S1-j for optical cross-connects Signal light is made to penetrate between the 1st optical input port and the 2nd optical output port and between the 3rd optical input port and the 4th optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 1st optical input port and the 2nd optical output port and except between the 3rd optical input port and the 4th optical output port, and] Or signal light is made to penetrate between the 1st optical input port and the 2nd optical output port and between the 4th optical input port and the 3rd optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 1st optical input port and the 2nd optical output port and except between the 4th optical input port and the 3rd optical output port, and] Or signal light is made to penetrate between the 1st optical input port and the 4th optical output port and between the 3rd optical input port and the 2nd optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 1st optical input port and the 4th optical output port and except between the 3rd optical input port and the 2nd optical output port, and] Or signal light is made to penetrate between the 1st optical input port and the 3rd optical output port and between the 4th optical input port and the 2nd optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 1st optical input port and the 3rd optical output

port and except between the 4th optical input port and the 2nd optical output port, and] Or signal light is made to penetrate between the 2nd optical input port and the 1st optical output port and between the 3rd optical input port and the 4th optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 2nd optical input port and the 1st optical output port and except between the 3rd optical input port and the 4th optical output port, and] Or signal light is made to penetrate between the 2nd optical input port and the 1st optical output port and between the 4th optical input port and the 3rd optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 2nd optical input port and the 1st optical output port and except between the 4th optical input port and the 3rd optical output port, and] Or signal light is made to penetrate between the 2nd optical input port and the 3rd optical output port and between the 4th optical input port and the 1st optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 2nd optical input port and the 3rd optical output port and except between the 4th optical input port and the 1st optical output port, and] Or signal light is made to penetrate between the 2nd optical input port and the 4th optical output port and between the 3rd optical input port and the 1st optical output port. And it can choose as arbitration whether signal light is intercepted among all the optical input port and optical output ports between the 2nd optical input port and the 4th optical output port and except between the 3rd optical input port and the 1st optical output port.

[0023] This invention according to claim 7 is set to this invention according to claim 5. Furthermore, said switch SP-j for optical cross-connects It is created on 1 or two or more PLC substrates, and each is equipped with the 1st, two 2nd optical input port and the 1st, and 2nd two optical output ports. Signal light is made to penetrate between the 1st optical input port and the 1st optical output port and between the 2nd optical input port and the 2nd optical output port. And [whether signal light is intercepted among all the optical input/output port between the 1st optical input port and the 1st optical output port and except between the 2nd optical input port and the 2nd optical output port, and] Or signal light is made to penetrate between the 1st optical input port and the 2nd optical output port and between the 2nd optical input port and the 1st optical output port. And between the 1st optical input port and the 2nd optical output port And the 1st thru/or 4th four 2x2 cross-bar actuation optical switch circuit CS-k ($k=1, 2, 3, 4$) which can choose as arbitration whether signal light is intercepted among all the optical input/output port except between the 2nd optical input port and the 1st optical output port, Each is equipped with the 1st and 2nd spectral separation side [two] light input/output port and multiplexing side [one] light input/output port. Signal light is made to penetrate between the 1st spectral separation side light input/output port and the 1st multiplexing side light input/output port. And [whether signal light is intercepted among all the optical input/output port except between the 1st spectral separation side light input/output port and the 1st multiplexing side light input/output port, and] Or signal light is made to penetrate between the 2nd spectral separation side light input/output port and the 1st multiplexing side light input/output port. And the 1st thru/or 4th four 2x1 transparency joint port selection optical switch circuit SS-i ($i=1, 2, 3, 4$) which can choose as arbitration whether signal light is intercepted among all the optical input/output port except between the 2nd spectral separation side light input/output port and the 1st multiplexing side light input/output port, The optical waveguide which connects the 1st optical input port of switch SP-j for optical cross-connects, and which 2nd optical input port of 2x2 cross-bar actuation optical switch circuit CS-1, The optical waveguide which connects the 2nd optical input port of switch

SP-j for optical cross-connects, and said 1st optical input port of 2x2 cross-bar actuation optical switch circuit CS-1, The optical waveguide which connects the 3rd optical input port of switch SP-j for optical cross-connects, and which 1st optical input port of 2x2 cross-bar actuation optical switch circuit CS-2 except said 2x2 cross-bar actuation optical switch circuit CS-1, The optical waveguide which connects the 4th optical input port of switch SP-j for optical cross-connects, and said 2nd optical input port of 2x2 cross-bar actuation optical switch circuit CS-2, The optical waveguide which connects the 1st optical output port of switch SP-j for optical cross-connects, and which 2nd optical output port of 2x2 cross-bar actuation optical switch circuit CS-3 except 2x2 cross-bar actuation optical switch circuit CS-1 and CS-2, The optical waveguide which connects the 2nd optical output port of switch SP-j for optical cross-connects, and the 1st optical output port of 2x2 cross-bar actuation optical switch circuit CS-3, The optical waveguide which connects the 3rd optical output port of switch SP-j for optical cross-connects, and which 1st optical output port of 2x2 cross-bar actuation optical switch circuit CS-4 except 2x2 cross-bar actuation optical switch circuit CS-1, CS-2, and CS-3, The optical waveguide which connects the 4th optical output port of switch SP-j for optical cross-connects, and the 2nd optical output port of 2x2 cross-bar actuation optical switch circuit CS-4, The optical waveguide which connects the 1st optical output port of 2x2 cross-bar actuation optical switch circuit CS-1, and which 2nd spectral separation side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-1, The optical waveguide which connects the 1st optical output port of 2x2 cross-bar actuation optical switch circuit CS-2, and said 1st spectral separation side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-1, The optical waveguide which connects the 2nd optical output port of 2x2 cross-bar actuation optical switch circuit CS-2, and which [except 2x1 transparency joint port selection optical switch circuit SS-1] 1st spectral separation side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-2, The optical waveguide which connects the 2nd optical output port of 2x2 cross-bar actuation optical switch circuit CS-1, and said 2nd spectral separation side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-2, The optical waveguide which connects the 1st optical input port of 2x2 cross-bar actuation optical switch circuit CS-3, and which [except SS-2] 2x1 transparency joint port selection optical switch circuit SS-1 and 1st [of 2x1 transparency joint port selection optical switch circuit SS-3] spectral separation side light input/output port, The optical waveguide which connects the 1st optical input port of 2x2 cross-bar actuation optical switch circuit CS-4, and the 1st spectral separation side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-3, The optical waveguide which connects the 2nd optical input port of 2x2 cross-bar actuation optical switch circuit CS-4, and which [except SS-3] 2x1 transparency joint port selection optical switch circuit SS-1, SS-2, and 2nd [of 2x1 transparency joint port selection optical switch circuit SS-4] spectral separation side light input/output port, The optical waveguide which connects the 2nd optical input port of 2x2 cross-bar actuation optical switch circuit CS-3, and the 1st spectral separation side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-4, The optical waveguide which connects the 1st multiplexing side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-1, and the 1st multiplexing side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-3, Let it be a summary to have the optical waveguide which connects the 1st multiplexing side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-2, and the 1st multiplexing side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-4.

[illegible]

port and the 1st optical output port and between the 4th optical input port and the 2nd optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 3rd optical input port and the 1st optical output port and except between the 4th optical input port and the 2nd optical output port, and] Or signal light is made to penetrate between the 4th optical input port and the 1st optical output port and between the 3rd optical input port and the 2nd optical output port. And it can choose as arbitration whether signal light is intercepted among all the optical input port and optical output ports between the 4th optical input port and the 1st optical output port and except between the 3rd optical input port and the 2nd optical output port.

[0025] This invention according to claim 8 makes it a summary for said 2x2 cross-bar actuation optical switch circuit CS-i to consist of a Mach TSUENDA mold flat-surface waveguide light TO switching circuit, a double-gate Mach TSUENDA mold flat-surface waveguide light TO switching circuit, a Mach TSUENDA mold flat-surface waveguide light LN switching circuit, a double-gate Mach TSUENDA mold flat-surface waveguide light LN switching circuit, or a semi-conductor light amplifier (SOA) mold 2x2 optical-switch circuit in this invention according to claim 6 or 7.

[0026] If it is in this invention according to claim 8, 2x2 cross-bar actuation optical switch circuit CS-i consists of a Mach TSUENDA mold flat-surface waveguide light TO switching circuit, a double-gate Mach TSUENDA mold flat-surface waveguide light TO switching circuit, a Mach TSUENDA mold flat-surface waveguide light LN switching circuit, a double-gate Mach TSUENDA mold flat-surface waveguide light LN switching circuit, or a semi-conductor light amplifier (SOA) mold 2x2 optical-switch circuit.

[0027] Moreover, this invention according to claim 9 is set to this invention according to claim 6 or 7. Said 2x1 transparency joint port selection optical switch circuit SS-i The inside of four optical input/output port of a Mach TSUENDA mold flat-surface waveguide light TO switching circuit, The inside of four optical input/output port of the thing realized using any three optical input/output port, or a double-gate Mach TSUENDA mold flat-surface waveguide light TO switching circuit, What was realized using any three optical input/output port, Or the inside of the optical waveguide which connects between the optical input/output port of the four Mach TSUENDA mold flat-surface waveguide light TO switching circuit section in the configuration of a double-gate Mach TSUENDA mold flat-surface waveguide light TO switching circuit, and these four Mach TSUENDA mold flat-surface waveguide light TO switching circuit section, The 2x1 transparency joint port selection optical switch circuit which consists of only optical waveguides which connect between the optical input/output port of the three Mach [any] TSUENDA mold flat-surface waveguide light TO switching circuit section and these three Mach TSUENDA mold flat-surface waveguide light TO switching circuit section, Or the inside of four optical input/output port of a Mach TSUENDA mold flat-surface waveguide light LN switching circuit, The inside of four optical input/output port of the thing realized using any three optical input/output port, or a double-gate Mach TSUENDA mold flat-surface waveguide light LN switching circuit, What was realized using any three optical input/output port, Or the inside of the optical waveguide which connects between the optical input/output port of the four Mach TSUENDA mold flat-surface waveguide light LN switching circuit section in the configuration of a double-gate Mach TSUENDA mold flat-surface waveguide light LN switching circuit, and these four Mach TSUENDA mold flat-surface waveguide light LN switching circuit section, Let it be a summary to consist of 2x1 transparency joint port selection optical switch circuits which consist of only optical waveguides which connect between the optical input/output port of the three Mach [any] TSUENDA mold flat-surface waveguide light LN switching circuit section

and these three Mach TSUENDA mold flat-surface waveguide light LN switching circuit section.

[0028] If it is in this invention according to claim 9, 2x1 transparency joint port selection optical switch circuit SS-i The inside of four optical input/output port of a Mach TSUENDA mold flat-surface waveguide light TO switching circuit, The inside of four optical input/output port of the thing realized using any three optical input/output port, or a double-gate Mach TSUENDA mold flat-surface waveguide light TO switching circuit, What was realized using any three optical input/output port, Or the inside of the optical waveguide which connects between the optical input/output port of the four Mach TSUENDA mold flat-surface waveguide light TO switching circuit section in the configuration of a double-gate Mach TSUENDA mold flat-surface waveguide light TO switching circuit, and these four Mach TSUENDA mold flat-surface waveguide light TO switching circuit section, The 2x1 transparency joint port selection optical switch circuit which consists of only optical waveguides which connect between the optical input/output port of the three Mach [any] TSUENDA mold flat-surface waveguide light TO switching circuit section and these three Mach TSUENDA mold flat-surface waveguide light TO switching circuit section, Or the inside of four optical input/output port of a Mach TSUENDA mold flat-surface waveguide light LN switching circuit, The inside of four optical input/output port of the thing realized using any three optical input/output port, or a double-gate Mach TSUENDA mold flat-surface waveguide light LN switching circuit, What was realized using any three optical input/output port, Or the inside of the optical waveguide which connects between the optical input/output port of the four Mach TSUENDA mold flat-surface waveguide light LN switching circuit section in the configuration of a double-gate Mach TSUENDA mold flat-surface waveguide light LN switching circuit, and these four Mach TSUENDA mold flat-surface waveguide light LN switching circuit section, It consists of 2x1 transparency joint port selection optical switch circuits which consist of only optical waveguides which connect between the optical input/output port of the three Mach [any] TSUENDA mold flat-surface waveguide light LN switching circuit section and these three Mach TSUENDA mold flat-surface waveguide light LN switching circuit section.

[0029] Furthermore, this invention according to claim 10 is set to this invention according to claim 6. All configuration optical circuits are created for said switching circuit S1-j for optical cross-connects on one PLC substrate flat surface. It sees from a substrate top face. Clockwise The 2nd optical output port of switching circuit S1-j for optical cross-connects, The 1st optical output port, the 3rd optical output port, the 4th optical output port, the 4th optical input port, It is arranged so that each optical input and output port may adjoin each other in order of the 3rd optical input port, the 1st optical input port, and the 2nd optical input port. The optical input/output port of 2x2 cross-bar actuation optical switch circuit CS-k (k= 1) sees from a substrate top face. Clockwise The 2nd optical input port, the 1st optical input port, the 1st optical output port, Are arranged so that each other may be adjoined in order of the 2nd optical output port, and the optical input/output port of four 2x1 transparency joint port selection optical switch circuit SS-i (i= 1, 2, 3, 4) sees from a substrate top face. Clockwise The 1st spectral separation side light input/output port, the 2nd spectral separation side light input/output port, By being arranged so that each other may be adjoined in order of the 1st multiplexing side light input/output port, and giving moderately spacing of each 2x2 cross-bar actuation optical switch circuit and a 2x1 transparency joint port selection optical switch circuit further Let it be a summary to be the arrangement which neither of the optical waveguides which connects between the optical input port of each 2x2 cross-bar actuation optical switch circuit and a 2x1

transparency joint port selection optical switch circuit and an optical output port intersects. [0030] If it is in this invention according to claim 10, as for switching circuit S1-j for optical cross-connects, all configuration optical circuits are created on one PLC substrate flat surface. It sees from a substrate top face. Clockwise The 2nd optical output port of switching circuit S1-j for optical cross-connects, The 1st optical output port, the 3rd optical output port, the 4th optical output port, the 4th optical input port, It is arranged so that each optical input and output port may adjoin each other in order of the 3rd optical input port, the 1st optical input port, and the 2nd optical input port. The optical input/output port of 2x2 cross-bar actuation optical switch circuit CS-k ($k=1$) sees from a substrate top face. Clockwise The 2nd optical input port, the 1st optical input port, the 1st optical output port, Are arranged so that each other may be adjoined in order of the 2nd optical output port; and the optical input/output port of four 2x1 transparency joint port selection optical switch circuit SS-i ($i=1, 2, 3, 4$) sees from a substrate top face. Clockwise The 1st spectral separation side light input/output port, the 2nd spectral separation side light input/output port, By being arranged so that each other may be adjoined in order of the 1st multiplexing side light input/output port, and giving moderately spacing of each 2x2 cross-bar actuation optical switch circuit and a 2x1 transparency joint port selection optical switch circuit further It is the arrangement which neither of the optical waveguides which connects between the optical input port of each 2x2 cross-bar actuation optical switch circuit and a 2x1 transparency joint port selection optical switch circuit and an optical output port intersects.

[0031] This invention according to claim 11 is set to this invention according to claim 7. Switch SP-j for cross connect All configuration optical circuits are created on one PLC substrate flat surface, and it sees from a substrate top face. Clockwise The 2nd optical output port of switch SP-j for optical cross-connects, The 1st optical output port, the 3rd optical output port, the 4th optical output port, the 4th optical input port, It is arranged so that each optical input and output port may adjoin each other in order of the 3rd optical input port, the 1st optical input port, and the 2nd optical input port. The optical input/output port of four 2x2 cross-bar actuation optical switch circuit CS-k ($k=1, 2, 3, 4$) sees from a substrate top face. Clockwise The 2nd optical input port, the 1st optical input port, the 1st optical output port, Are arranged so that each other may be adjoined in order of the 2nd optical output port, and the optical input/output port of four 2x1 transparency joint port selection optical switch circuit SS-i ($i=1, 2, 3, 4$) sees from a substrate top face. Clockwise The 1st spectral separation side light input/output port, the 2nd spectral separation side light input/output port, By being arranged so that each other may be adjoined in order of the 1st multiplexing side light input/output port, and giving moderately spacing of each 2x2 cross-bar actuation optical switch circuit further In which optical waveguide which connects between the optical input port of each 2x2 cross-bar actuation optical switch circuit, and an optical output port Between the 2nd optical output port of 2x2 cross-bar actuation optical switch circuit CS-1, and the 2nd spectral separation side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-2, The optical waveguide which connects between the 1st optical output port of 2x2 cross-bar actuation optical switch circuit CS-2, and the 1st spectral separation side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-1, respectively, Between the 2nd optical input port of 2x2 cross-bar actuation optical switch circuit CS-3, and the 1st spectral separation side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-4, and the 1st optical input port of 2x2 cross-bar actuation optical switch circuit CS-4 2 sets with the optical waveguide which connects between the 2nd spectral separation side light input/output port of 2x1

transparency joint port selection optical switch circuit SS-3, respectively, respectively Every one place, Only a total of two places cross and let it be a summary to be arrangement without the crossover of the optical waveguide which connects between the other optical input port and an optical output port.

[0032] If it is in this invention according to claim 11, as for switch SP-j for cross connect, all configuration optical circuits are created on one PLC substrate flat surface. It sees from a substrate top face. Clockwise The 2nd optical output port of switch SP-j for optical cross-connects, The 1st optical output port, the 3rd optical output port, the 4th optical output port, the 4th optical input port, It is arranged so that each optical input and output port may adjoin each other in order of the 3rd optical input port, the 1st optical input port, and the 2nd optical input port. The optical input/output port of four 2x2 cross-bar actuation optical switch circuit CS-k ($k=1, 2, 3, 4$) sees from a substrate top face. Clockwise The 2nd optical input port, the 1st optical input port, the 1st optical output port, Are arranged so that each other may be adjoined in order of the 2nd optical output port, and the optical input/output port of four 2x1 transparency joint port selection optical switch circuit SS-i ($i=1, 2, 3, 4$) sees from a substrate top face. Clockwise The 1st spectral separation side light input/output port, the 2nd spectral separation side light input/output port, By being arranged so that each other may be adjoined in order of the 1st multiplexing side light input/output port, and giving moderately spacing of each 2x2 cross-bar actuation optical switch circuit further In which optical waveguide which connects between the optical input port of each 2x2 cross-bar actuation optical switch circuit, and an optical output port Between the 2nd optical output port of 2x2 cross-bar actuation optical switch circuit CS-1, and the 2nd spectral separation side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-2, The optical waveguide which connects between the 1st optical output port of 2x2 cross-bar actuation optical switch circuit CS-2, and the 1st spectral separation side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-1, respectively, Between the 2nd optical input port of 2x2 cross-bar actuation optical switch circuit CS-3, and the 1st spectral separation side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-4, and the 1st optical input port of 2x2 cross-bar actuation optical switch circuit CS-4 Only a total of two places cross one place at a time, respectively, and 2 sets with the optical waveguide which connects between the 2nd spectral separation side light input/output port of 2x1 transparency joint port selection optical switch circuit SS-3, respectively have become arrangement without the crossover of the optical waveguide which connects between the other optical input port and an optical output port.

[0033] Moreover, this invention according to claim 12 makes it a summary for said light wave length multiplexing/demultiplexing circuit to be an array waveguide mold light wave length multi/demultiplexer (AWG:arrayed-waveguide grating) in this invention according to claim 5.

[0034] If it is in this invention according to claim 12, a light wave length multiplexing/demultiplexing circuit is an array waveguide mold light wave length multi/demultiplexer.

[0035] Furthermore, this invention according to claim 13 is set to this invention according to claim 5. One array waveguide flat-surface optical circuit WM-1 with all the waveguides for optical I/O that do not cross mutually [form the set A-1 about wavelength multiplexing/demultiplexing, A-2, A-3, and A-4, and], One array waveguide flat-surface optical circuit WM-2 with all the waveguides for optical I/O that do not cross mutually [form the set A-5 about wavelength multiplexing/demultiplexing, A-6, A-7, and A-8, and], Switching circuit S1-j for 4 input 4 output optical cross-connects and SP-j by which it is

arranged according to an individual respectively corresponding to each wavelength channel, and those either is arranged for every wavelength channel, and optical circuit S3-j, Optical input/output port and switching circuit S1-j for 4 input 4 output optical cross-connects of said array waveguide flat-surface optical circuit WM-1 and WM-2, In the light wave length multiplexing/demultiplexing circuit and the switching circuit section for optical cross-connects which consist of optical waveguides which connect the ports corresponding to each of the optical input port of SP-j and optical circuit S3-j ($j = 1, 2, \dots, N$), and an optical output port The optical input/output port corresponding to wavelength channel λ_{dai} of arbitration by which [a clockwise rotation or / counter clockwise] the surroundings by the optical I/O waveguide by the side of spectral separation of said the set of array waveguide flat-surface optical circuit WM-1 of each The 2nd, the 1st, the 3rd, the 4th spectral separation side light input/output port It has stood in a line in order of (A-I/O-d-2-i, A-I/O-d-1-i, A-I/O-d-3-i, A-I/O-d-4-i). and between the optical input/output port located in a line with such sequence The ** into which the optical input/output port by the side of the spectral separation from which the optical input/output port and the corresponding wavelength channel by the side of all other multiplexing differ does not enter, Optical input/output port has accomplished the ensemble respectively in location for every corresponding wavelength channel. The optical input/output port corresponding to wavelength channel λ_{dai} of arbitration sets to said array waveguide flat-surface optical circuit WM-1 by the optical I/O waveguide by the side of spectral separation of said the set of array waveguide flat-surface optical circuit WM-2 of each. The surroundings from which optical input/output port serves as sequence of the 2nd, 1st, 3rd, and 4th spectral separation side light input/output port (A-I/O-d-2-i, A-I/O-d-1-i, A-I/O-d-3-i, A-I/O-d-4-i) to the circumference of reverse The 6th, the 5th, the 7th, the 8th spectral separation side light input/output port It has stood in a line in order of (A-I/O-d-6-i, A-I/O-d-5-i, A-I/O-d-7-i, A-I/O-d-8-i). and between the optical input/output port located in a line with such sequence The ** into which the optical input/output port by the side of the spectral separation from which the optical input/output port and the corresponding wavelength channel by the side of all other multiplexing differ does not enter, Optical input/output port has accomplished the ensemble respectively in location for every corresponding wavelength channel. Furthermore, it is related with the wavelength channel to which the ensembles of the optical input/output port for every wavelength channel by the side of spectral separation correspond. The sequence of the list about the wavelength channel to which the ensembles of the optical input/output port for every wavelength channel by the side of the sequence of ***** and said spectral separation of array waveguide flat-surface optical circuit WM-1 correspond is the sequence mutually same at the circumference of reverse. Furthermore, each switching circuit S1-j for 4 input 4 output optical cross-connects, SP-j, And it is related with the wavelength channel to which the ensembles of the optical output port of optical circuit S3-j ($j = 1, 2, \dots, N$) correspond. The sequence of the list about the wavelength channel to which the ensembles of the optical input/output port for every wavelength channel by the side of the sequence of ***** and said spectral separation of array waveguide flat-surface optical circuit WM-1 correspond is the same sequence by the mutually same surroundings. And each switching circuit S1-j for 4 input 4 output optical cross-connects, SP-j, And it is related with the wavelength channel to which the ensembles of the optical output port of optical circuit S3-j ($j = 1, 2, \dots, N$) correspond. When the sequence of the list about the wavelength channel to which the ensembles of the optical input/output port for every wavelength channel by the side of the sequence of ***** and said spectral separation of array waveguide flat-surface optical circuit WM-1 correspond is the sequence mutually same at the circumference of reverse

On the same flat surface, array waveguide flat-surface optical circuit WM-1, WM-2 and switching circuit S1 for 4 input 4 output optical cross-connects-j, It is the arrangement and the configuration of a circuit in which one does not have what crosses mutually by the optical waveguides which connect SP-j and optical circuit S3-j ($j = 1, 2, \dots, N$). Array waveguide flat-surface optical circuit WM-1, WM-2 and switching circuit S1-j for 4 input 4 output optical cross-connects, SP-j, and optical circuit S3-j ($j = 1, 2, \dots, N$), Array waveguide flat-surface optical circuit WM-1, WM-2, and switching circuit S1-j for 4 input 4 output optical cross-connects, [whether the optical waveguide which connects between SP-j and optical circuit S3-j ($j = 1, 2, \dots, N$), respectively is created on the same flat-surface substrate, and] Or each optical input/output port is combined in the form which compares and carries out the flat-surface circuit board of the light wave length multiplexing/demultiplexing section and the flat-surface circuit board of the switching circuit for optical cross-connects by which the individual exception was created; and let it be a summary to form one plane optical circuit.

[0036] One array waveguide flat-surface optical circuit WM-1 with all the waveguides for optical I/O that do not cross mutually [if it is in this invention according to claim 13 / form the set A-1 about wavelength multiplexing/demultiplexing, A-2, A-3, and A-4, and], One array waveguide flat-surface optical circuit WM-2 with all the waveguides for optical I/O that do not cross mutually [form the set A-5 about wavelength multiplexing/demultiplexing, A-6, A-7, and A-8, and], Switching circuit S1-j for 4 input 4 output optical cross-connects and SP-j by which it is arranged according to an individual respectively corresponding to each wavelength channel, and those either is arranged for every wavelength channel, and optical circuit S3-j, Optical input/output port and switching circuit S1-j for 4 input 4 output optical cross-connects of said array waveguide flat-surface optical circuit WM-1 and WM-2, In the light wave length multiplexing/demultiplexing circuit and the switching circuit section for optical cross-connects which consist of optical waveguides which connect the ports corresponding to each of the optical input port of SP-j and optical circuit S3-j ($j = 1, 2, \dots, N$), and an optical output port The optical input/output port corresponding to wavelength channel λ_{dai} of arbitration by which [a clockwise rotation or / counter clockwise] the surroundings by the optical I/O waveguide by the side of spectral separation of said the set of array waveguide flat-surface optical circuit WM-1 of each The 2nd, the 1st, the 3rd, the 4th spectral separation side light input/output port It has stood in a line in order of (A-I/O-d-2-i, A-I/O-d-1-i, A-I/O-d-3-i, A-I/O-d-4-i). and between the optical input/output port located in a line with such sequence The ** into which the optical input/output port by the side of the spectral separation from which the optical input/output port and the corresponding wavelength channel by the side of all other multiplexing differ does not enter, Optical input/output port has accomplished the ensemble respectively in location for every corresponding wavelength channel. The optical input/output port corresponding to wavelength channel λ_{dai} of arbitration sets to said array waveguide flat-surface optical circuit WM-1 by the optical I/O waveguide by the side of spectral separation of said the set of array waveguide flat-surface optical circuit WM-2 of each. The surroundings from which optical input/output port serves as sequence of the 2nd, 1st, 3rd, and 4th spectral separation side light input/output port (A-I/O-d-2-i, A-I/O-d-1-i, A-I/O-d-3-i, A-I/O-d-4-i) to the circumference of reverse The 6th, the 5th, the 7th, the 8th spectral separation side light input/output port It has stood in a line in order of (A-I/O-d-6-i, A-I/O-d-5-i, A-I/O-d-7-i, A-I/O-d-8-i). and between the optical input/output port located in a line with such sequence The ** into which the optical input/output port by the side of the spectral separation from which the optical input/output port and the corresponding wavelength channel by the side of all other multiplexing differ does not

enter, Optical input/output port has accomplished the ensemble respectively in location for every corresponding wavelength channel. Furthermore, it is related with the wavelength channel to which the ensembles of the optical input/output port for every wavelength channel by the side of spectral separation correspond. The sequence of the list about the wavelength channel to which the ensembles of the optical input/output port for every wavelength channel by the side of the sequence of ***** and said spectral separation of array waveguide flat-surface optical circuit WM-1 correspond is the sequence mutually same at the circumference of reverse. Furthermore, each switching circuit S1-j for 4 input 4 output optical cross-connects, SP-j, And it is related with the wavelength channel to which the ensembles of the optical output port of optical circuit S3-j ($j = 1, 2, \dots, N$) correspond. The sequence of the list about the wavelength channel to which the ensembles of the optical input/output port for every wavelength channel by the side of the sequence of ***** and said spectral separation of array waveguide flat-surface optical circuit WM-1 correspond is the same sequence by the mutually same surroundings. And each switching circuit S1-j for 4 input 4 output optical cross-connects, SP-j, And it is related with the wavelength channel to which the ensembles of the optical output port of optical circuit S3-j ($j = 1, 2, \dots, N$) correspond. When the sequence of the list about the wavelength channel to which the ensembles of the optical input/output port for every wavelength channel by the side of the sequence of ***** and said spectral separation of array waveguide flat-surface optical circuit WM-1 correspond is the sequence mutually same at the circumference of reverse On the same flat surface, array waveguide flat-surface optical circuit WM-1, WM-2 and switching circuit S1 for 4 input 4 output optical cross-connects-j, It is the arrangement and the configuration of a circuit in which one does not have what crosses mutually by the optical waveguides which connect SP-j and optical circuit S3-j ($j = 1, 2, \dots, N$). Array waveguide flat-surface optical circuit WM-1, WM-2 and switching circuit S1-j for 4 input 4 output optical cross-connects, SP-j, and optical circuit S3-j ($j = 1, 2, \dots, N$), Array waveguide flat-surface optical circuit WM-1, WM-2, and switching circuit S1-j for 4 input 4 output optical cross-connects, [whether the optical waveguide which connects between SP-j and optical circuit S3-j ($j = 1, 2, \dots, N$), respectively is created on the same flat-surface substrate, and] Or each optical input/output port is combined in the form which compares and carries out the flat-surface circuit board of the light wave length multiplexing/demultiplexing section and the flat-surface circuit board of the switching circuit for optical cross-connects by which the individual exception was created, and one plane optical circuit is formed.

[0037] This invention according to claim 14 is set to said optical circulator in this invention according to claim 9. The light into which the light inputted into optical input port was outputted from optical input/output port, and was inputted from optical input/output port The light which is outputted from an optical output port, is inputted from optical input/output port and outputted from optical input port The light which is fully oppressed, is inputted from an optical output port, and is outputted from optical input/output port makes it a summary to fully be oppressed, and not to be concerned with the sense of I/O of light between optical input port and an optical output port, but to fully oppress light.

[0038] If it is in this invention according to claim 14, in an optical circulator, the light inputted into optical input port The light which was outputted from optical input/output port and inputted from optical input/output port The light which is outputted from an optical output port, is inputted from optical input/output port and outputted from optical input port The light which is fully oppressed, is inputted from an optical output port, and is outputted from optical input/output port is fully oppressed, between optical input port and

an optical output port, it is not concerned with the sense of I/O of light, but light is fully oppressed.

[0039]

[Embodiment of the Invention] Hereafter, the gestalt of operation of this invention is explained using a drawing.

[0040] First, the definition of the expression used with this operation gestalt is indicated below.

[0041] [Definition 1] Set A ($A = \{a\}$) and [External Character 1] of input/output port which use input/output port a as the only element when the set L of the wavelength channel of 1:1 when there is set B of the input/output port which does not contain certain input/output port a and this input/output port a in an element and the transmitted wave length channel between said input/output port a is made to correspond by making the set B of input/output port into a domain which is the range of a map (onto one-to-one mapping) exists

It will express, if the set about ***** multiplexing/demultiplexing is formed, and said input/output port a is expressed as the input/output port by the side of multiplexing, and it is expressed as the input/output port by the side of spectral separation of the input/output port which is the element of the set B of said input/output port.

[0042] [Definition 2] The set A of two relatively prime input/output port (waveguide) There is B ($A \cdot B = \phi$). Every at least one transmitted wave length channel in the wavelength field of the input/output port (waveguide) which is the element of the set A of input/output port (waveguide), and the input/output port (waveguide) which is the element of the set B of input/output port (waveguide) made into a problem among all input/output port (waveguide) exists respectively. When a transmitted wave length channel does not exist between the input/output port in each set (waveguide) () Namely, when the signal light L is inputted from input/output port (waveguide) a with the element of the set A of input/output port (waveguide), The signal light L is outputted from any of the element of the set B of input/output port (waveguide), or corresponding input/output port (waveguide) b. Conversely, when the signal light L is inputted from input/output port [of the element of the set B of input/output port (waveguide)] (waveguide) b, The signal light L is outputted from input/output port [of the element of the set A of input/output port (waveguide)] (waveguide) a. Between the elements of the set A of input/output port, and between the elements of the set B of input/output port Signal light is outputted and inputted and it twists, and the sets A and B of input/output port (waveguide) will be expressed if it becomes input port (waveguide) and an output port (waveguide) complementary mutually.

[0043] next, as a light wave length multiplexing/demultiplexing circuit used in the optical circuit for an optical pass arrangement of this invention When AWG which is the important optical components on the configuration of desirable AWG and the configuration of the optical circuit of this invention, and this AWG are required of the light wave length multiplexing/demultiplexing circuit which constitutes the optical circuit concerning this invention, a property, That is, certification satisfied [of the property that two or more relatively prime sets can be formed] with the set of the input/output port about the wavelength multiplexing/demultiplexing to the set of a wavelength channel with the optical input/output port which one AWG has is shown.

[0044] First, the configuration of AWG is explained with reference to drawing 1 . Drawing 1 is $N \times N$. It is drawing showing the circuitry of AWG ($N = 16$).

[0045] NxN shown in drawing 1 AWG (N= 16) The two slab waveguide sections 10-1, 10-2, and the optical I/O waveguide section 9-1 and 9-2 that were connected to each of these two slab waveguide sections, Between said two slab waveguide sections 10-1 and 10-2 are connected, and it consists of the array waveguide grating sections 11 which consist of a meeting of the suitable optical waveguide with contiguity waveguide length which carries out fixed-length [every] monotonous increment or monotonous reduction.
[0046] Moreover, the optical I/O waveguide section 9-1 and 9-2 become input waveguide and output waveguide complementary respectively mutually, and consist of sets of the I/O waveguide each number of elements of whose is N individual.

[0047] Furthermore, NxN AWG (N= 16) has LP= {L-P.n} (n= 1, 2, --, 16) which is the set of the input/output port which turns into input port and an output port complementary mutually, and RP= {R-P.m} (m= 1, 2, --, 16).

[0048] however, several input/output port of fleece PEKUTORARU (FSR), wavelength channel spacing (deltalambda), and one side -- between N -- $N = \text{FSR} / \text{delta} \text{ -- } \lambda$ -- by the optical waveguide which constitutes the optical I/O waveguide section 9-1 prolonged from one slab waveguide 10-1 of NxNAWG which has satisfied relation To the input/output port which each optical waveguide draws sequentially from the optical waveguide side which adjoined the longest optical waveguide of the waveguide length of the two slab waveguide sections 10-1 and the array waveguide grating section 11 which connects 10-2, and has been prolonged, 1, 2, --, Notation L-P. which discriminates the set of the input/output port which assigned N and a port number and has extended from one slab waveguide 10-1 from the set of the input/output port which has extended from the slab waveguide 10-2 of another side, and L in all-P.1, L-P.2, --, Expressed L-P.N and it has extended from the slab waveguide 10-2 of another side. To the input/output port which each optical waveguide draws sequentially from the optical waveguide side which constitutes the two slab waveguide sections 10-1 and the optical I/O waveguide section 9-2 which adjoined the longest optical waveguide of the waveguide length of the array waveguide grating section 11 who connects 10-2, and has been prolonged, 1, 2, --, N and a port number are assigned and let the sets of the input/output port which has extended from the slab waveguide 10-2 be notation R-P. discriminated from the set of the input/output port which has extended from the slab waveguide 10-1, R in all-P.1, R-P.2 and --, and the thing to express as R-P.N.

[0049] Next, AWG performs certification about what the property required of the light wave length multiplexing/demultiplexing circuit which constitutes the light amplifier concerning this invention is satisfied for.

[0050] L-P.1 which consists each input/output port of a notation which identifies input/output port, and an input/output port number as mentioned above, L-P.2, --, L-P.N, R-P.1, R-P.2, --, when it expresses with R-P.N, NxN AWG (main transmitted wave length channel λ_{dac} , wavelength channel spacing λ_{delta}) complementary mutually Input port, The transmitted wave length $\lambda(n, m)$ of input/output port L-P.n (n is the natural number below N) and input/output port R-P.m (m is the natural number below N) used as an output port uses the input/output port numbers n and m, and is [Equation 1].
$$\lambda(n, m) = \lambda_{\text{dac}} + m - N/2 = \lambda_{\text{dac}} + \lambda_{\text{delta}} (n + m - N/2) \quad (0 < n + m - N/2 \leq N) \quad -- (1)$$

$$= \lambda_{\text{dac}} + m + N/2 = \lambda_{\text{dac}} + \lambda_{\text{delta}} (n + m + N/2) \quad (n + m - N/2 \leq 0) \quad -- (2)$$

$$= \lambda_{\text{dac}} + m - 3N/2 = \lambda_{\text{dac}} + \lambda_{\text{delta}} (n + m - 3N/2) \quad (N < n + m - N/2) \quad -- (3)$$

It can express.

[0051] For example, NxN at the time of assigning a number suitably to input/output port, as mentioned above The transmitted wave length between input/output port L-P.6, L-P.7,

L-P.8, L-P.9, and input/output port {R-P.m} (m= 1, 2, --, 16) of AWG (N= 16, FSR=Ndelta lambda) becomes relation as shown in a table 1.

[0052]

[A table 1]

Here, it is NxN. The property required of the light wave length multiplexing/demultiplexing circuit where AWG is needed for the light amplifier of this invention is satisfied, Namely, the integer j of the arbitration which satisfies $10 < j < N$ is received. In *****, the set {L-P.j-1, R-P.2k"+2 (k"=0, 1 and 2, --, N / 2-1)} of {L-P.j, R-P.2K'+1 (K'=0, 1 and 2, --, N / 2-1)} and input/output port is relatively prime. It is shown that it is the set about the wavelength multiplexing/demultiplexing to the set of the same wavelength channel.

[0053] First, the integer k of the arbitration which satisfies the integer j of the arbitration which satisfies $0 < j < N$, $0 \leq k \leq N / 2 - 1$ is received. It asks for relation with the transmitted wave length lambda (j-1, 2k+2) between the ports of the transmitted wave length lambda between the ports of input/output port L-P.j and input/output port R-P.2k+1 (j, 2k+1), input/output port L-P.j-1, and input/output port R-P.2k+2 below.

[0054] The integers k and j of the above-mentioned arbitration are used for the sum of the port number between the ports which become each other with input port and an output port complementary in the group of 2 sets of above-mentioned input/output port, and it is $n+m=2k+1+j=2k+2+(j-1)$.

It can express and both value always becomes equal.

[0055] Therefore, for the above-mentioned transmitted wave length lambda (j, 2k+1) and lambda (j-1, 2k+2), since it is expressed by which same formula of the above-mentioned formula (1), (2), or (3) by any case, the difference with the transmitted wave length lambda (j, 2k+1) and lambda (j-1, 2k+2) is [Equation 2].

$$\lambda(j, 2k+1) - \lambda(j-1, 2k+2) \\ = \text{delta}\lambda([2k+1]+j-N/2) - \text{delta}\lambda([2k+2]+[j-1]-N/2)$$

$$= 0 \text{ or [Equation 3]}$$

$$\lambda(j, 2k+1) - \lambda(j-1, 2k+2) \\ = \text{delta}\lambda([2k+1]+j+N/2) - \text{delta}\lambda([2k+2]+[j-1]+N/2)$$

$$= 0 \text{ or [Equation 4]}$$

$$\lambda(j, 2k+1) - \lambda(j-1, 2k+2) \\ = \text{delta}\lambda([2k+1]+j-3N/2) - \text{delta}\lambda([2k+2]+[j-1]-3N/2)$$

= It is set to 0 and, in any case, it turns out that it is the same wavelength.

[0056] It follows. $0 < j < N$ Case L'={ of the transmitted wave length between input/output port L-P.j to the integer j of the arbitration to satisfy, and the input/output port which is the element of $C = \{R-P.2k'+1 : k'=0, 1 \text{ and } 2, \dots, N / 2 - 1\}$ in the case of input/output port] $\lambda(j, 2k'+1) : k'=0, 1 \text{ and } 2, \dots, N/2-1$, input/output port L-P. -- set L"= of the transmitted wave length between j-1 and the input/output port which is the element of set $D = \{R-P.2k"+2 : k"=0, 1 \text{ and } 2, \dots, N / 2 - 1\}$ of input/output port -- $\lambda(j-1, 2k"+2) : k"=0, 1, 2 \dots, \text{ and }] 2-1$ Since the elements which satisfy $k'=k''$ are equal respectively, it is equal ($L'=L''$).

[0057] Furthermore At this time Set C[of the input/output port by the side of spectral separation] = {R-P.2k'+1} The difference of a port number with set D[of N/2-1), and input/output port] = {R-P.2k"+2} ($k"=0, 1, \dots, N/2-1$) can express $(2k'+1)-(2k"+2)=2(k'-k'')-1$. ($k'=0, 1, \text{ and } \dots$ It turns out that C and D are relatively prime in the case of input/output port, and it does not have the common element (input/output port) of each

other since a value is never set to 0 also to the combination of k'' , natural number [what kind of] k' and.

[0058] It follows. The set $\{L-Pj, R-P.2k'+1 (k'=0, 1 \text{ and } 2, \dots, N/2-1)\}$ of the input/output port to the integer j of the arbitration which satisfies $0 \leq j \leq N$, and set $\{L-Pj-1$ of input/output port and $R-P.2k''+2 (k''=0, 1 \text{ and } 2, \dots, N/2-1)$ are relatively prime. And it is the set about the wavelength multiplexing/demultiplexing to the set of the same wavelength channel.

[0059] moreover The integer of the arbitration which satisfies $0 < j < N$ similarly is received at j . Set $\{L-P.j \text{ of } \text{*****}, R-P.3k'+1 \text{ (} k'=0, 1 \text{ and } 2, \dots, N/3-1)\}$, and set $\{L-P.j-2 \text{ of the set } \{L-P.j-1, R-P.3k''+2 \text{ (} k''=0, 1 \text{ and } 2, \dots, N/3-1)\}$ of input/output port, and input/output port and $R-P.3k - \dots - +3 \text{ (} K - \dots - =0, 1 \text{ and } 2, \text{ and } \dots)$ As opposed to the integer k of the arbitration which satisfies $0 \leq k < N/2$ about $N/3-1$ } The sum of the port number between the ports which turn into input port and an output port complementary can express $n+m=j+(3k+1)=(j-1)+(3k+2)=(J-2)+(3k+3)$ to each other using the integers k and j of the above-mentioned arbitration. The difference of the port number of the multiplexing side port during the set of each input/output port which has three persons' value in an always equal thing and the above, [Equation 5]

($3k'+1$)-($3k''+2$)= $3(k' - k'')$ -1 ($3k'+1$) -($3k''' +3$)= $3(k' - k''')$ -2 ($3k''+2$) - ($3k''' +3$) -- = -- three ($k'' - k'''$) - three -- what kind of -- the natural number -- $k - k'' - k'''$ -- receiving -- As opposed to the integer j of the arbitration which satisfies $0 < j < N$ since it **** and is not set to 0 Set {L-P.j of ***** , R-P. $3k'+1$ ($k'=0, 1$ and $2, \dots, N / 3-1$)}, and set {L-P.j-2 of the set {L-P.j-1, R-P. $3k''+2$ ($k''=0, 1$ and $2, \dots, N / 3-1$)} of input/output port, and input/output port and R-P. $3k - k''' +3$ ($k - k''' =0, 1$ and 2 , and --) It is the set about the wavelength multiplexing/demultiplexing to the set of the wavelength channel same relatively prime as $N/3-1$ }.

[0060] Further again As opposed to the integer j of the arbitration which satisfies $0 < j < N$ similarly Set {L-P.J of *****}, R-P.4k'+1 (k'=0, 1 and 2, --, N / 4-1)}, and set {L-P.j-1 of input/output port and R-P.4k' -- 'set {L-P.j-2 of +2(k''=0, 1 and 2, --, N / 4-1)} and input/output port, R-P.4k''' -- +3 (k -- "' -- =0, 1 and 2, and --) N/4-1}, and set {L-P.j-3 of input/output port, R-P.4k'''+ (as opposed to the integer k of the arbitration which satisfies $0 \leq k < N/2$ about $4(k'''=0, 1 \text{ and } 2, \text{ --, } N / 4-1)$)) The sum of the port number between the ports which turn into input port and an output port complementary can express $n+m=j+(4k+1)=(j-1)+(4k+2)=(j-2)+(4k+3)=(j-3)+(4k+4)$ to each other using the integers k and j of the above-mentioned arbitration, and four persons are always equal, And the difference of the port number of the multiplexing side port during the set of each input/output port which exists above, [Equation 6]

input/output port which exists above, [Equation 6]
 $(4k'+1) - = 4 (4k''+2) (k'-k'') - 1 (4k'+1) - = 4 (4k'''+3) (k'-k''') - 2 (4k'+1) - = 4 (4k'''+4)$
 $(k'-k'''' - 3 (4k''+2) - = 4 (4k'''+3) (k''-k''') - 1 (-- four -- k -- ' -- ' -- + -- two --) - (4k'''+4) -- =$
 $-- four (k'' - k''') - two (4k'''+3) - (4k'''+4) -- = -- four 'k'''-k -- '' - one -- what kind of -- the$
 natural number -- k -- ' -- k -- ' -- ' -- k -- ' -- ' -- ' -- receiving -- As opposed to the integer j
 of the arbitration which satisfies $0 < j < N$ since it **** and is not set to 0 Set {L-P.j of
 *****, R-P. $4k'+1$ ($k'=0, 1$ and $2, --, N / 4-1$)}, and set {L-P.j-1 of input/output
 port and R-P. $4k'$ -- 'set {L-P.j-2 of $+2(k''=0, 1$ and $2, --, N / 4-1)$ } and input/output port,
 R-P. $4k''' -- +3 (k -- '' -- =0, 1$ and $2, and --)$. The set {L-P.j-3, R-P. $4k'''+4$ ($k'''=0, 1$ and $2, --,$
 $N / 4-1)$ of $N/4-1$ }, and input/output port is a set about the wavelength
 multiplexing/demultiplexing to the set of the same relatively prime and wavelength
 channel].

[0061] Hereafter, several N' of a set of input/output port and N to form are N/N'. - The same thing can be said as long as $1 \geq 0$ is satisfied.

[0062] As mentioned above, NxN AWG is relatively prime and it turns out that the property required of the light wave length multiplexing/demultiplexing circuit which is needed for the light amplifier of this invention with the set of two or more input/output port which forms a set about the wavelength multiplexing/demultiplexing to the set of the same wavelength channel is satisfied.

[0063] Satisfying the property required of the light wave length multiplexing/demultiplexing circuit which constitutes the light amplifier AWG starts this invention as mentioned above is proved.

[0064] Next, while it is shown that it is the switch configuration with which are satisfied of all actuation that switching circuit S1-j for optical cross-connects shown in drawing 2 should fill, it is shown that it is the switch configuration with which are satisfied of all actuation that switch SP-j for optical cross-connects shown in drawing 3 should fill.

[0065] Switching circuit S1-j for optical cross-connects shown in drawing 2 consists of one 2 input 2 output cross-bar actuation optical switch circuit CS-i ($i=1$) and four 2x1 transparency joint port selection optical switch circuit SS-i ($i=1, 2, 3, 4$).

[0066] Moreover, switch SP-j for optical cross-connects shown in drawing 3 consists of four 2 input 2 output cross-bar actuation optical switch circuit CS-i ($i=1, 2, 3, 4$) and four 2x1 transparency joint port selection optical switch circuit SS-i ($i=1, 2, 3, 4$).

[0067] Two optical input/output port CS-i-I -1 of 2 input 2 output cross-bar actuation optical switch circuit CS-i which is a component here Transparency / cutoff switching between CS-i-I-optical input/output port CS-i-O -1 of 2 and 2 and CS-i-O -2 the actuation (0-condition concerning CS-j at this operation gestalt --) which changes two operating state as generally called cross-bar switching and shown in a table 2 (a) to arbitration 1-condition is possible. And transparency / cutoff switching between one two optical input/output port SS-i-I/O-L -1 of 2x1 transparency joint port selection optical switch circuit SS-i, SS-i-I/O-L -2, and optical input/output port SS-i-I/O-R -1 of another side For example, are in agreement with transparency / cutoff switching which observed only optical remaining input/output port CS-i-I -1, CS-i-I -2, and CS-i-O -1, without making optical output port CS-i-O -2 of the above-mentioned 2 input 2 output cross-bar actuation optical switch circuit into a problem. The actuation (0-condition concerning SS-j at this operation gestalt, 1-condition) which changes two operating state as shown in a table 2 (b) to arbitration is possible.

[0068]

[A table 2]

[A table 3]

As an optical switch circuit which realizes transparency / cutoff switching of such a cross-bar mold A Mach TSUENDA mold flat-surface waveguide light TO switching circuit (refer to IEICE.Trans.Electron., E76-C, p.1215, and 1993), A double-gate Mach TSUENDA mold flat-surface waveguide light TO switching circuit (refer to Electron Letter 32., p.1471, and 1996), A Mach TSUENDA mold flat-surface waveguide light LN switching circuit, a double-gate Mach TSUENDA mold flat-surface waveguide light LN switching circuit, There is a semi-conductor light amplifier (SOA) mold 2x2 optical-switch circuit (refer to Yoshiro Komatsu, OPTRONICS No.12, pp.139-144, and 1997) etc.

[0069] Actuation of 2x1 transparency joint port selection optical switch circuit SS-i is

realized by simplifying a circuit in the range which does not affect switching, not using one input/output port of the arbitration of an optical switch circuit which realizes the above-mentioned cross-bar mold transparency / cutoff switching.

[0070] Switching circuit S1-j for optical cross-connects as shown in drawing 2 by 2 input 2 output cross-bar actuation optical switch circuit CS-1 and 2x1 transparency joint port selection optical switch circuit SS-i ($i = 1, 2, 3, 4$) which were mentioned above is constituted. Transparency between optical input port and an optical output port and cutoff switching can be realized by switching circuit S1-j for optical cross-connects by making it operate, making it align so that it may become combination as shows the operating state of the optical switch circuit which is each component in a table 3 (a).

[0071]

[A table 4]

That is, switching circuit S1-j for optical cross-connects realizes the following actuation.

[0072] Signal light is made to penetrate between the 1st optical input port and the 2nd optical output port and between the 3rd optical input port and the 4th optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 1st optical input port and the 2nd optical output port and except between the 3rd optical input port and the 4th optical output port, and] Or signal light is made to penetrate between the 1st optical input port and the 2nd optical output port and between the 4th optical input port and the 3rd optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 1st optical input port and the 2nd optical output port and except between the 4th optical input port and the 3rd optical output port, and] Or signal light is made to penetrate between the 1st optical input port and the 4th optical output port and between the 3rd optical input port and the 2nd optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 1st optical input port and the 4th optical output port and except between the 3rd optical input port and the 2nd optical output port, and] Or signal light is made to penetrate between the 1st optical input port and the 3rd optical output port and between the 4th optical input port and the 2nd optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 1st optical input port and the 3rd optical output port and except between the 4th optical input port and the 2nd optical output port, and] Or signal light is made to penetrate between the 2nd optical input port and the 1st optical output port and between the 3rd optical input port and the 4th optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 2nd optical input port and the 1st optical output port and except between the 3rd optical input port and the 4th optical output port, and] Or signal light is made to penetrate between the 2nd optical input port and the 1st optical output port and between the 4th optical input port and the 3rd optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 2nd optical input port and the 1st optical output port and except between the 4th optical input port and the 3rd optical output port, and] Or signal light is made to penetrate between the 2nd optical input port and the 3rd optical output port and between the 4th optical input port and the 1st optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 2nd optical input port and the 3rd optical output port and except between the 4th optical input port and the 1st optical output port, and] Or signal light is made to penetrate between the 2nd optical input port and the

4th optical output port and between the 3rd optical input port and the 1st optical output port. And switching circuit S1-j for optical cross-connects can choose as arbitration whether signal light is intercepted among all the optical input port and optical output ports between the 2nd optical input port and the 4th optical output port and except between the 3rd optical input port and the 1st optical output port.

[0073] Moreover, switch SP-j for optical cross-connects as shown in drawing 3 by 2 input 2 output cross-bar actuation optical switch circuit CS-i ($i = 1, 2, 3, 4$) and 2x1 transparency joint port selection optical switch circuit SS-i ($i = 1, 2, 3, 4$) is constituted. Transparency between optical input port and an optical output port and cutoff switching can be realized by switch SP-j for optical cross-connects by making it operate, making it align as a combination as shows the operating state of the optical switch circuit which is each component in a table 3 (b).

[0074]

[A table 5]

That is, switch SP-j for optical cross-connects can realize the following actuation.

[0075] Signal light is made to penetrate between the 1st optical input port and the 2nd optical output port and between the 3rd optical input port and the 4th optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 1st optical input port and the 2nd optical output port and except between the 3rd optical input port and the 4th optical output port, and] Or signal light is made to penetrate between the 1st optical input port and the 2nd optical output port and between the 4th optical input port and the 3rd optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 1st optical input port and the 2nd optical output port and except between the 4th optical input port and the 3rd optical output port, and] Or signal light is made to penetrate between the 1st optical input port and the 4th optical output port and between the 3rd optical input port and the 2nd optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 1st optical input port and the 4th optical output port and except between the 3rd optical input port and the 2nd optical output port, and] Or signal light is made to penetrate between the 1st optical input port and the 3rd optical output port and between the 4th optical input port and the 2nd optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 1st optical input port and the 3rd optical output port and except between the 4th optical input port and the 2nd optical output port, and] Or signal light is made to penetrate between the 2nd optical input port and the 1st optical output port and between the 3rd optical input port and the 4th optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 2nd optical input port and the 1st optical output port and except between the 3rd optical input port and the 4th optical output port, and] Or signal light is made to penetrate between the 2nd optical input port and the 1st optical output port and between the 4th optical input port and the 3rd optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 2nd optical input port and the 1st optical output port and except between the 4th optical input port and the 3rd optical output port, and] Or signal light is made to penetrate between the 2nd optical input port and the 3rd optical output port and between the 4th optical input port and the 1st optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 2nd optical input port and the 3rd

optical output port and except between the 4th optical input port and the 1st optical output port, and] Or signal light is made to penetrate between the 2nd optical input port and the 4th optical output port and between the 3rd optical input port and the 1st optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 2nd optical input port and the 4th optical output port and except between the 3rd optical input port and the 1st optical output port, and] Or signal light is made to penetrate between the 1st optical input port and the 3rd optical output port and between the 2nd optical input port and the 4th optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 1st optical input port and the 3rd optical output port and except between the 2nd optical input port and the 4th optical output port, and] Or signal light is made to penetrate between the 1st optical input port and the 4th optical output port and between the 2nd optical input port and the 3rd optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 1st optical input port and the 4th optical output port and except between the 2nd optical input port and the 3rd optical output port, and] Or signal light is made to penetrate between the 3rd optical input port and the 1st optical output port and between the 4th optical input port and the 2nd optical output port. And [whether signal light is intercepted among all the optical input port and optical output ports between the 3rd optical input port and the 1st optical output port and except between the 4th optical input port and the 2nd optical output port, and] Or signal light is made to penetrate between the 4th optical input port and the 1st optical output port and between the 3rd optical input port and the 2nd optical output port. And switch SP-j for optical cross-connects can choose as arbitration whether signal light is intercepted among all the optical input port and optical output ports between the 4th optical input port and the 1st optical output port and except between the 3rd optical input port and the 2nd optical output port.

[0076] Furthermore, switching circuit S1-j for optical cross-connects is 2 input 2 output cross-bar actuation optical switch circuit CS-1 which is a component as drawing 2 also shows. Arrangement creation can be carried out on the same flat surface, without 2x1 transparency joint port selection optical switch circuit SS-i ($i = 1, 2, 3, 4$) and the optical waveguide which connects between external I/O ports crossing.

[0077] Moreover, switch SP-j for optical cross-connects can be arranged and created on the same flat surface so that drawing 3 may show, and there may be no part which 2 input 2 output cross-bar actuation optical switch circuit CS-i which is a component, 2x1 transparency joint port selection optical switch circuit SS-i, and two optical waveguides which connect between external I/O ports cross, in addition crosses.

[0078] Although it is possible to suppress and create the increment in loss by making the intersection of optical waveguide into the cross talk between each optical waveguide and the crossing structure when creating the switching circuit for optical cross-connects in this invention on one flat-surface substrate Since an actual creation top is difficult for making a cross talk into zero thoroughly, and making thoroughly the increment in loss by making it the crossing structure into zero, The arrangement configuration of the switching circuit for optical cross-connects of this invention [whether when accumulating and creating a circuit on one flat-surface substrate, the cross talk and loss resulting from the crossover structure of optical waveguide can be thoroughly made into zero, and] Or since it becomes a flat-surface circuit without the part which has at most two intersections, in addition crosses, the flat-surface mold optical circuit which was excellent in the property about loss and a cross talk can be created, and it is advantageous.

[0079] Furthermore, 2 input 2 output cross-bar actuation optical switch circuit CS-j which

is the component of switching circuit S1-j for optical cross-connects. It is the switch which controls the cross connect of two signal light streams especially. Especially this switch A Mach TSUENDA mold flat-surface waveguide light LN switching circuit, By considering as the optical switch circuit which can realize high-speed optical switching like a double-gate Mach TSUENDA mold flat-surface waveguide light LN switching circuit and a semi-conductor light amplifier (SOA) mold 2x2 optical-switch circuit A change rate can realize a high-speed change in the signal light packet unit of nsec order to sub-nsec order. At this time, a Mach TSUENDA mold flat-surface waveguide light LN switching circuit and a double-gate Mach TSUENDA mold flat-surface waveguide light LN switching circuit have a comparatively large insertion loss. Since a semi-conductor light amplifier (SOA) mold 2x2 optical-switch circuit deteriorates signal light slightly by NF of SOA using a Mach TSUENDA mold flat-surface waveguide light TO switching circuit or a double-gate Mach TSUENDA mold flat-surface waveguide light TO switching circuit -- the insertion loss of switching circuit S1-j for optical cross-connects -- it can penetrate and degradation of signal light can be suppressed.

[0080] Next, with reference to drawing 4 and drawing 5, the detail of the optical circuit section CORE (optical control means) currently used for the optical circuit for an optical pass arrangement and this optical circuit for an optical pass arrangement concerning the operation gestalt of this invention is explained.

[0081] In the example of the optical circuit section CORE shown in drawing 5, the set about the wavelength multiplexing/demultiplexing to set LO[of the same wavelength channel] = $\{\lambda_{4k+q+1}\}$ is formed as a light wave length multiplexing/demultiplexing circuit, and it is the set [several 7] of four relatively prime optical input/output port. $PG-1=A-3=\{L-P.q, R-P.4K+q+1\}$, $PG-2=A-1=\{L-P.q-1, R-P.4K+q+2\}$, $PG-3=A-4=\{L-P.q+1, R-P.4K+q\}$, $PG-4=A-2=\{L-P.q-2, N \times N \text{ which has } R-P.4K+q+3\}$ AWG The set about the wavelength multiplexing/demultiplexing to WM-1 and the set LO of said wavelength channel is formed, and it is the set [several 8] of four relatively prime optical input/output port. $PG-5=A-7=\{L-P.q, R-P.4K+q+1\}$, $PG-6=A-5=\{L-P.q-1, R-P.4K+q+2\}$, $PG-7=A-8=\{L-P.q+1, R-P.4K+q\}$, $PG-8=A-6=\{L-P.q-2, R-P.4K+q+3\}$ AWG A total of two $N \times N$ which consists of WM-2 It is constituted using AWG.

[0082] In addition, please refer to table 4a shown below as a conversion table of optical input/output port to a transmitted wave length channel, a table 4 (b), a table 4 (c), a table 4 (d), and a table 4 (e). A table 4 (c) is the case of $q-4m=3$, a table 4 (a) is the case of $q-4m \leq 2$, and table 4e is [a table 4 (b) is the case of $1 \leq q-4m \leq 3$, and / a table 4 (d) is the case where it has a full circumference property by $q-4m=0$ and $N=2q$, and] an example in $N=32$.

[0083]

[A table 6]

[A table 7]

[A table 8]

[A table 9]

[A table 10]

However, it is $m = \text{int}(q/4)$ here. It is $q = \text{int}(N/2)$. At the time of $q-4m < 1$ It is 1, 0, --, $m-1$. $k = -m+1$, --, - at the time of $1 \leq q-4m < 3$ Or when it has $q-6m=0$, $N=2q$, and a full circumference property, it is $k = -m$, $-m+1$, --, -1, 0 and 1, --, $m-1$, and they are $k = -m$, $-m+1$, --, -1, 0 and 1, --, $m-1$, and m at the time of $q-6m=3$.

[0084] Furthermore, optical input/output port A-I/O -1, A-I/O -2, A-I/O -3 and A-I/O -4, and optical multiplexing/demultiplexing circuit NxN AWG Optical input/output port L-P.q by the side of multiplexing of WM-1, L-P.q The optical input/output port where +1, L-P.q-1, and L-P.q-2 are the same respectively is expressed. And optical input/output port A-I/O-d-1-i, A-I/O-d-2-i, A-I/O-d-3-i and A-I/O-d-4-i, and optical multiplexing/demultiplexing circuit NxN AWG Optical input/output port R-P.i+1 by the side of spectral separation of WM-1, R-P.i, The optical input/output port where R-P.i+2 and R-P.i+3 are the same respectively is expressed. And optical input/output port R-P.q by the side of multiplexing of optical input/output port A-I/O -5, A-I/O -6, A-I/O -7 and A-I/O -8, and optical multiplexing/demultiplexing circuit NxNAWG WM -2, R-P.q +1, R-P.q The optical input/output port where -1 and R-P.q-2 are the same respectively is expressed. And optical input/output port A-I/O-d-5-i, A-I/O-d-6-i, A-I/O-d-7-i and A-I/O-d-8-i, and optical multiplexing/demultiplexing circuit NxNAWG Optical input/output port L-P.i+1 by the side of spectral separation of WM-2, L-P.i, L-P.i+2, and L-P.i+3 shall express the same optical input/output port, respectively.

[0085] So that by choosing the combination of optical input/output port as mentioned above may show from table 4a, b, c and d, and drawing 5 The input/output port by the side of the spectral separation corresponding to the same wavelength channel of set PG-n ($n=1, 2, 3, 4$) of optical input/output port, And it becomes possible to make a group form without making the optical input port of an arrangement top and others enter inside of the input/output port by the side of the spectral separation corresponding to the same wavelength channel of set PG-n ($n=5, 6, 7, 8$) of optical input/output port.

[0086] It follows. NxN AWG Optical input/output port R-P.6 $k+q+1$ by the side of the spectral separation corresponding to the same wavelength channel of set PG-n ($n=1, 2, 3, 4$) of the input/output port about the wavelength multiplexing/demultiplexing to L0 of WM-1, R-P.6 $k+q$, R-P.6 $k+q+2$, And respectively corresponding to each wavelength channel, it is arranged according to an individual with R-P.6 $k+q+3$. And optical input port S-j-I -1 of switching circuit S1-j for optical cross-connects and SP-j by which it is arranged for every wavelength channel those any they are, and ($j=4k+q+1$) optical circuit S3-j, S-j-I -2, S-j-I -3, and S-j-I -4 respectively -- optical waveguide -- an epilogue -- and NxN AWG Optical input/output port L-P.6 $k+q+1$ by the side of the spectral separation corresponding to the same wavelength channel of set P-n ($n=7, 8, \dots, 12$) of the input/output port about the wavelength multiplexing/demultiplexing to L0 of WM-2, L-P.6 $k+q$, L-P.6 $k+q+2$, And respectively corresponding to each wavelength channel, it is arranged according to an individual with L-P.6 $k+q+3$. And optical output port S-j-O -1 of switching circuit S1-j for optical cross-connects and SP-j by which it is arranged for every wavelength channel those any they are, and ($j=4k+q+1$) optical circuit S3-j, S-j-O -2, S-j-O -3, and S-j-O -4 It is optical multiplexing/demultiplexing circuit NxN by making it the circuit arrangement connected with optical waveguide, respectively. AWG Respectively corresponding to WM-1, WM-2, and each wavelength channel, it is arranged according to an individual. And, without making all the optical waveguides that connect

between the input/output port of each switching circuit S1-j for cross connect and SP-j by which it is arranged for every wavelength channel those any they are, and ($j=4k+q+1$) optical circuit S3-j cross It is possible to arrange and create these optical circuits on the same flat surface.

[0087] Although it is possible to suppress and create the increment in loss by making the intersection of optical waveguide into the cross talk between each optical waveguide and the crossing structure Since an actual creation top is difficult for making a cross talk into zero thoroughly, and making thoroughly the increment in loss by making it the crossing structure into zero, Optical multiplexing/demultiplexing circuit NxN of this invention AWG Respectively corresponding to WM-1, WM-2, and each wavelength channel, it is arranged according to an individual. And the arrangement configuration of the optical waveguide which connects between input/output port with switching circuit S1-j for optical cross-connects and SP-j by which it is arranged for every wavelength channel those any they are, and ($j=4k+q+1$) optical circuit S3-j optical multiplexing/demultiplexing circuit NxN when integrating and creating a circuit on one flat-surface substrate AWG WM-1 and WM-2 and switching circuit S1 for optical cross-connects-j -- or When the whole circuit is constituted by creating SP-j as a flat-surface substrate optical circuit according to an individual, respectively, making each optical input/output port associate, and connecting (I. Ogawa et.al, OFC'98PD 4-1), The cross talk and loss resulting from the crossover structure of optical waveguide can be thoroughly made into zero, and it is advantageous.

[0088] Furthermore, between the transparency and operating characteristic in each wavelength channel between the optical input/output port of the optical circuit section CORE, and the switch condition of switching circuit S1-j for optical cross-connects, SP-j, and ($j=4k+q+1$) arranged corresponding to each wavelength channel, response relation as shown in a table 5 (a) and a table 5 (b), respectively is materialized.

[0089]

[A table 11]

[A table 12]

Furthermore, optical input/output port I/O-n of the optical circuit for an optical pass arrangement of this invention ($n=1, 2, 3, 4$), Optical input/output port CL-I/O-n ($n=1, 2, 3, 4$) of optical circulator CL-n ($n=1, 2, 3, 4$) by optical waveguide, respectively An epilogue, And between optical output port CL-O-n ($n=1, 2, 3, 4$) of optical circulator CL-n ($n=1, 2, 3, 4$), and optical input port A-I/O-n ($n=1, 2, 3, 4$) of the optical circuit section CORE Uni-directional light amplifier AMP-n ($n=1, 2, 3, 4$) of a conventional type is connected to the sense by which optical amplification is carried out in the direction spread from optical output port CL-O-n to optical output port A-I/O-n, respectively. And optical output port A-I/O-n of the optical circuit section CORE ($n=5, 6, 7, 8$), By connecting optical input port CL-i-n ($n=1, 2, 3, 4$) of optical circulator CL-n ($n=1, 2, 3, 4$) with optical waveguide, respectively The transparency and operating characteristic in each wavelength channel between the optical input/output port of the optical circuit section CORE at the time of using switching circuit S1-j for optical cross-connects, and SP-j ($j=4k+q+1$), respectively, Between the optical propagation magnification conditions of the signal light between external I/O port I/O-n ($n=1, 2, 3, 4$) in the wavelength channel to which the optical circuit for an optical pass arrangement of this invention

corresponds, respectively, the response relation shown in table 6a. and table 6b., respectively is materialized.

[A table 13]

[A table 14]

therefore, which switching circuit S1-j for optical cross-connects arranged according to an individual corresponding to each wavelength channel -- and By controlling the switch condition of SP-j ($j=4k+q+1$), between a table 5 (a) and a table 6 (a), And according to the response relation shown between table 5b. and table 6b., respectively, the optical propagation magnification condition between external I/O port I/O-n ($n=1, 2, 3, 4$) in each corresponding wavelength channel of the optical circuit for a pass arrangement of this invention is controllable.

[0090] Namely, the conventional optical cross-connect circuit which has every two extraneous light input port and external optical output ports, respectively As opposed to being only being able to change and control a cross and two kinds of optical propagation magnification conditions of a bar, as shown in drawing 6 in the optical circuit for an optical pass arrangement of this invention When switching circuit S1-j for optical cross-connects is used, it adds to change control of the optical propagation magnification condition of a cross bar. extraneous light input/output port I/O -1, between I/O -2 and I/O -3, and I/O, since it is alike, respectively, it sets -4 between and dynamic change control of the two optical propagation magnification directions of rise and fall according to individual is attained for every wavelength channel It becomes possible to control the change of eight kinds of optical propagation magnification conditions as shown in drawing 7 .

[0091] moreover, when switch SP-j for optical cross-connects is used To change control of the optical propagation magnification condition of a cross bar, in addition, since dynamic change control of the two optical propagation magnification directions of rise and fall according to individual is attained for every wavelength channel among 2 ports of the arbitration of extraneous light input/output port I/O -1, I/O -2, I/O -3, and I/O -4, It becomes possible to control the change of 12 kinds of optical propagation magnification conditions as shown in drawing 8 .

[0092] This function is dramatically effective in the object which builds and controls the optical network which can expand the degree of freedom at the time of setting the pass of signal light on an optical network by leaps and bounds, and can respond to fluctuation of the amount of traffic flexibly.

[0093] Moreover, when it is decided in the actual network to use the pass of some wavelength channels by immobilization, It changes to said switching circuit S1-j for optical cross-connects, and switch SP-j for optical cross-connects. It has the optical circuit S3-j, i.e., the 1st, thru/or 4th optical input port and 1st thru/or 4th optical output port. Optical waveguide between the 1st optical input port and the 2nd optical output port and between the 3rd optical input port and the 4th optical output port An epilogue, Carry out termination of all the other optical input port and optical output ports, or optical waveguide between the 1st optical input port and the 2nd optical output port and between the 4th optical input port and the 3rd optical output port An epilogue, Carry out termination of all the other optical input port and optical output ports, or optical waveguide between the 1st optical input port and the 4th optical output port and between

the 3rd optical input port and the 2nd optical output port An epilogue, Carry out termination of all the other optical input port and optical output ports, or optical waveguide between the 1st optical input port and the 3rd optical output port and between the 4th optical input port and the 2nd optical output port An epilogue, Carry out termination of all the other optical input port and optical output ports, or optical waveguide between the 2nd optical input port and the 1st optical output port and between the 3rd optical input port and the 4th optical output port An epilogue, Carry out termination of all the other optical input port and optical output ports, or optical waveguide between the 2nd optical input port and the 1st optical output port and between the 4th optical input port and the 3rd optical output port An epilogue, Carry out termination of all the other optical input port and optical output ports, or optical waveguide between the 2nd optical input port and the 3rd optical output port and between the 4th optical input port and the 1st optical output port An epilogue, Carry out termination of all the other optical input port and optical output ports, or optical waveguide between the 2nd optical input port and the 4th optical output port and between the 3rd optical input port and the 1st optical output port An epilogue, Carry out termination of all the other optical input port and optical output ports, or optical waveguide between the 1st optical input port and the 3rd optical output port and between the 2nd optical input port and the 4th optical output port An epilogue, Carry out termination of all the other optical input port and optical output ports, or optical waveguide between the 1st optical input port and the 4th optical output port and between the 2nd optical input port and the 3rd optical output port An epilogue, Carry out termination of all the other optical input port and optical output ports, or optical waveguide between the 3rd optical input port and the 4th optical output port and between the 4th optical input port and the 2nd optical output port An epilogue, Carry out termination of all the other optical input port and optical output ports, or optical waveguide between the 4th optical input port and the 1st optical output port and between the 3rd optical input port and the 2nd optical output port An epilogue, By arranging 4 input 4 output optical circuit S3-j which suited realizing the pass of one the immobilization of said of one 4 input 4 output optical circuit S3-j of whether termination of all the other optical input port and optical output ports is carried out It can do [stopping power consumption or] by attaining simplification of the optical circuit for an optical pass arrangement of this invention, and excluding the unnecessary optical switch section.

[0094] Furthermore, they are $N=64$ and wavelength channel spacing $\Delta\lambda=25\text{GHz}$ $N \times N$ by the circuitry shown, for example in drawing 5. When AWG is used as a light wave length multiplexing/demultiplexing circuit, wavelength channel several $Ns/6=10$, and the wavelength channel spacing $6\Delta\lambda=150\text{GHz}$ ($\sim 1.2\text{nm}$) optical circuit for an optical pass arrangement can be realized.

[0095] Moreover, if an erbium fiber is further used as this rare earth addition fiber using the rare earth addition optical fiber of semiconductor laser excitation as the optical amplification section of light amplifier AMP-j ($j=1, 2, 3, 4$), the magnification wavelength band of a light amplifier will become between about 1.53×10^6 to $1.56 \times 10^6 \text{m}$ including the zero distribution wavelength field of a distributed shift fiber.

[0096] Furthermore, it is $N \times N$ as a light wave length multiplexing/demultiplexing circuit like drawing 5 mentioned above. When AWG is used, the optical loss of a hit even a light wave length multiplexing/demultiplexing circuit ideal -- about 1.0dB -- (-- J. -- C.Chen, et.al, IEEE PTL, vol.10, No.3, pp 379-381, and 1998) -- Loss of circuit S1-j for optical cross-connects at the time of using a double-gate Mach TSUENDA mold flat-surface waveguide light TO switching circuit and SP-j Less than (A. Himeno et.al,

ECOC'96ThD.2.2) 5dB, When a semi-conductor light amplifier (SOA) mold 2x2 optical-switch circuit is used, loss of circuit S1-j for optical cross-connects and SP-j 0dB (I. Ogawa et.al, OFC'98PD 4-1), Whenever loss of an optical circulator penetrates once, loss of a hit even association to about 1dB and an optical fiber as what has sufficiently short about 0.25dB and optical fiber further for circuit connection When it is estimated as what can disregard the loss and the optical amplification gain of a light amplifier is further estimated at about 30dB (1995 autumn SHINGAKUKAI collected works C-216 besides Funabashi) at the time of the input signal reinforcement of -20dBm, the optical amplification gain of the net of the optical circuit for an optical pass arrangement is [Equation 9]. It is estimated as $30 - 1.0 \times 2 - 5.0(0) - 1.0 \times 2 - 0.25 \times 4 = 30 - 10 = 20$ (25) dB. Therefore, it becomes possible to guarantee 18.4dB of loss of each section in the lightwave transmission system of 0.23dB/km of repeating span average optical fiber loss of 80km.

[0097] Moreover, NxN For the amount of crosstalk of AWG, the usual thing is [about]. -It is what attained low cross talk-ization using 25dB and a phase compensating plate, and is [about]. -If it is estimated as 40dB, and the (1997 autumn SHINGAKUKAI collected works C-3-119) besides Yamada and the isolation of about 40dB and an optical circulator is further estimated for the isolation of an optical isolator at about 50dB, an excavation by the wavelength channel of arbitration will be suppressed like the usual light amplifier.

[0098] Moreover, it is [Equation 10] when the optical resonator which consists of two wavelength channels of the arbitration from which two Fresnel reflection (-14dB) points which approach and exist before and behind the light amplifier exterior, and the propagation directions differ in the shape of a loop formation is assumed. Since it is estimated as 30×2 (gain of the optical amplification section per resonator 1 round trip) - $\{14 + 1.0 \times 2 + 25 [40] \times 2\} \times 2$ (optical loss per resonator 1 round trip) = $72 [-132]$ dB, and resonator internal loss is large and net gain is not acquired overwhelmingly, even if it is such worst case, the oscillation of the light amplifier in this operation gestalt is suppressed.

[0099] As mentioned above, the inside of an optical fiber is spread to the propagation of arbitration about going up and the direction of going down by the optical circuit for an optical pass arrangement of this operation gestalt for every wavelength channel, respectively. Or optical amplification is carried out. every [and] wavelength channel -- the need -- responding -- each propagation direction -- up Rika going down, responding the wavelength multiple-signal light belonging to two streams accompanied by a dynamic change of changing to lower Rika going up each time, and securing the isolation to the propagation of signal light And while eight kinds of optical propagation magnification conditions shown in drawing 7 realized by performing an optical cross-connect for every wavelength channel are realizable Moreover, input/output port is chosen as arbitration in the range which does not overlap to four signal light input/output port, respectively for every wavelength channel. Signal light can be made to be able to output and input and 12 kinds of optical propagation magnification conditions shown in drawing 8 which is all the combination that carries out propagation magnification of the two signal light streams can be realized.

[0100]

[Effect of the Invention] As explained above, according to this invention, the inside of an optical fiber is spread to the propagation of arbitration about going up and the direction of going down for every wavelength channel, respectively. Or optical amplification is carried out. every [and] wavelength channel -- the need -- responding -- each propagation direction -- up Rika going down, responding the wavelength multiple-signal light

belonging to two streams accompanied by a dynamic change of changing to lower Rika going up each time, and securing the isolation to the propagation of signal light And eight kinds of optical propagation magnification conditions realized by performing an optical cross-connect for every wavelength channel are realizable.

[0101] Moreover, according to this invention, input/output port can be chosen as arbitration in the range which does not overlap to four signal light input/output port, respectively for every wavelength channel, signal light can be made to be able to output and input, and 12 kinds of optical propagation magnification conditions which are all the combination that carries out propagation magnification of the two signal light streams can be realized.

[Translation done.]

* NOTICES *

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is drawing showing the configuration of an array waveguide mold optical multiplexer/demultiplexer.

[Drawing 2] It is drawing showing the configuration of switching circuit S1-j for optical cross-connects used for 1 operation gestalt of this invention.

[Drawing 3] It is drawing showing the configuration of switch SP-j for optical cross-connects used for 1 operation gestalt of this invention.

[Drawing 4] It is drawing showing the configuration of the optical circuit for an optical pass arrangement concerning 1 operation gestalt of this invention.

[Drawing 5] It is drawing showing the detailed configuration of the optical circuit section CORE currently used for the optical circuit for an optical pass arrangement shown in drawing 4 .

[Drawing 6] It is the mimetic diagram showing two optical propagation magnification conditions between each optical input port which the conventional optical cross-connect circuit realizes, and an optical output port.

[Drawing 7] It is the mimetic diagram showing eight typical optical propagation magnification conditions between each optical input/output port which the optical circuit for an optical pass arrangement of this invention realizes (when switching circuit S1-j for optical cross-connects and switch SP-j for optical cross-connects are used).

[Drawing 8] It is the mimetic diagram showing the typical optical propagation magnification condition of 12 between each optical input/output port which the optical circuit for an optical pass arrangement of this invention realizes (when switch SP-j for optical cross-connects is used).

[Drawing 9] It is drawing showing the configuration of the conventional optical cross-connect circuit.

[Drawing 10] It is drawing showing the configuration of the conventional optical ad drop circuit.

[Drawing 11] It is drawing showing the configuration of the conventional uni-directional light amplifier.

[Drawing 12] It is drawing showing the configuration of a light amplifier.

[Description of Notations]

0-1, 0-3, 0-3-i (i= 1, 2, --, n) Extraneous light input port

0-2, 0-4, 0-4-i (i= 1, 2, --, n) External optical output port

1-i (i= 1, 2, 3, 4) Light amplifier

1-i-1 Optical amplification section

1-i-2-1, 1-i-2-2 Optical isolator

2-i (i= 1, 2, 3, 4) Optical multiplexing length multi/demultiplexer

3-i (i= 1, 2, --, n) 2 input 2 output cross-bar actuation optical switch circuit

4 Rare Earth Addition Optical Fiber

5-1, 5-2 Laser for excitation

6-1, 6-2 Optical isolator

7-1, 7-2 Wavelength multiplexing/demultiplexing coupler

8 Flat-Surface Mold Waveguide Base

9-1, 9-2 Optical I/O waveguide section

10-1, 10-2 Slab waveguide section

11 Array Waveguide Grating Section

L-P. i (i= 1, 2, --, n) Optical input/output port

R-P. i (i= 1, 2, --, n) Optical input/output port

S1-j (j= 1, 2, --, n) Switching circuit for optical cross-connects

S2-j (j= 1, 2, --, n) Switching circuit for optical cross-connects

S-j-I-i (j= 1, 2, --, n; i= 1, 2, 3, 4) Optical input port

S-j-O-i (j= 1, 2, --, n; i= 1, 2, 3, 4) Optical output port

S-j-ADD -1, S-j-ADD -2 Optical input port

S-j-DROP -1, S-j-DROP -2 Optical output port

CS-i (i= 1, 2, --, n) 2 input 2 output cross-bar actuation optical switch circuit

CS-i-I-j (1 i= 1, 2, --, n; j= 2) Optical input port

CS-i-O-j (1 i= 1, 2, --, n; j= 2) Optical output port

SS-i (i= 1, 2, --, n) 2x1 transparency joint port selection optical switch circuit

SS-i-I/O-L-j (1 i= 1, 2, --, n; j= 2) Optical input/output port

SS-i-I/O-R -1 Optical input/output port

I/O-i (i= 1, 2, 3, 4) Extraneous light input/output port

ADD-I -1, ADD-I -2 Extraneous light input port

DROP-O -1, DROP-O -2 External optical output port

CL-i (i= 1, 2, 3, 4) Optical circulator (3 port molds)

CL-I/O-i (i= 1, 2, 3, 4) Optical input/output port

CL-I-i (i= 1, 2, 3, 4) Optical input port

CL-O-i (i= 1, 2, 3, 4) Optical output port

AMP-i (i= 1, 2, 3, 4) Uni-directional light amplifier

CORE Optical circuit section

A-I/O-i (i= 1, 2, --, 12) Optical input/output port

WM-1, WM-2 Light wave length multiplexing/demultiplexing circuit

S3-i 4 input 4 output optical circuit

[Translation done.]

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DRAWINGS

[Drawing 1]

[Drawing 6]

[Drawing 2]

[Drawing 3]

[Drawing 4]

[Drawing 5]

[Drawing 7]

[Drawing 8]

[Drawing 9]

[Drawing 11]

[Drawing 10]

[Drawing 12]

[Translation done.]

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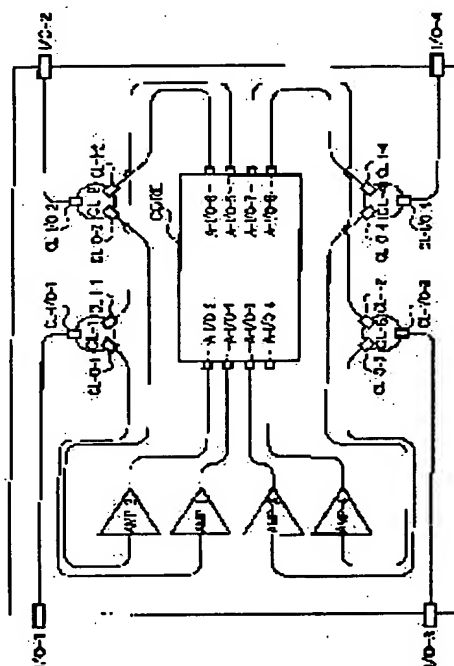
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(54) OPTICAL CIRCUIT FOR OPTICAL PATH ARRANGEMENT

(57)Abstract:

PROBLEM TO BE SOLVED: To provide an optical circuit for optical path arrangement that can realize light ways of light propagation amplification states and twelve ways of light propagation amplification states by amplifying a signal light while ensuring isolation of the signal light in the propagation direction with respect to incoming and outgoing directions by each wavelength channel in an optical fiber and applying optical cross connect to each wavelength channel.

SOLUTION: The optical circuit for optical path arrangement consisting of optical circulators CL-1, 2, 3, 4, unidirectional optical amplifiers AMP-1, 2, 3, 4, and an optical circuit section CORE interconnects four external optical input output ports I/O-1, 2, 3, 4 to realize the 8 ways of light propagation amplification states shown in Figure 7 and the 12 ways of light propagation amplification states shown in Figure 8.



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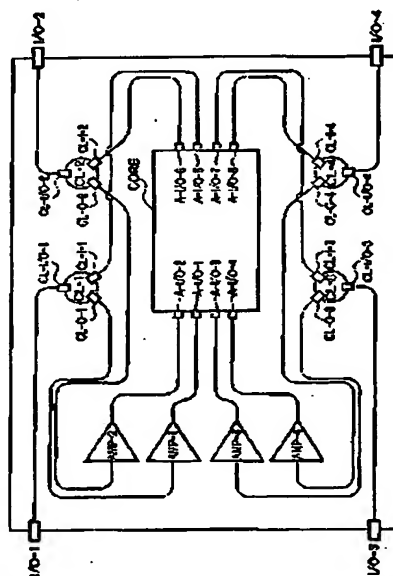
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(54)【発明の名称】 光バス・アレンジ用光回路

(57)【要約】

【課題】 光ファイバ中をそれぞれの波長チャンネル毎に上りおよび下り方向に関して信号光の伝搬方向へのアイソレーションを確保しつつ光増幅し、かつ各波長チャンネル毎に光クロスコネクトを行うことにより8通りの光伝搬増幅状態および12通りの光伝搬増幅状態を実現し得る光バス・アレンジ用光回路を提供する。

【解決手段】 光サーキュレータCL-1, 2, 3, 4, 片方向光増幅器AMP-1, 2, 3, 4, および光回路部COREからなる光バス・アレンジ用光回路により4つの外部光入出力ポートI/O-1, 2, 3, 4の間を接続することにより、図7に示す8通りの光伝搬増幅状態および図8に示す12通りの光伝搬増幅状態を実現することができる。



前記第1乃至第4の光サーキュレータのそれぞれの光入 50

カポートとの間および第4の光入力ポートと第1の光出

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の入出力ポートと第3の片方向光増幅手段の光出力ポートとを結ぶ光導波路と、
光波長台分波回路の光入出力ポートの集合A-1、A-2、A-3以外の何れかの集合A-4の要素である台波側の第4の入出力ポートと第4の片方向光増幅手段の光出力ポートとを結ぶ光導波路と、
光波長台分波回路の光入出力ポートの集合A-1、A-2、A-3、A-4以外の何れかの集合A-5の要素である台波側の第5の入出力ポートと第1の光サーキュレータの光入力ポートとを結ぶ光導波路と、
光波長台分波回路の光入出力ポートの集合A-1、A-2、A-3、A-4、A-5以外の何れかの集合A-6の要素である台波側の第6の入出力ポートと第2の光サーキュレータの光入力ポートとを結ぶ光導波路と、
光波長台分波回路の光入出力ポートの集合A-1、A-2、A-3、A-4、A-5、A-6以外の何れかの集合A-7の要素である台波側の第7の入出力ポートと第3の光サーキュレータの光入力ポートとを結ぶ光導波路と、
光波長台分波回路の光入出力ポートの集合A-1、A-2、A-3、A-4、A-5、A-6、A-7以外の何れかの集合A-8の要素である台波側の第8の入出力ポートと第4の光サーキュレータの光入力ポートとを結ぶ光導波路と、
前記第1の片方向光増幅手段の光入力ポートと前記第1の光サーキュレータの光出力ポートとを結ぶ光導波路と、
前記第2の片方向光増幅手段の光入力ポートと前記第2の光サーキュレータの光出力ポートとを結ぶ光導波路と、
前記第3の片方向光増幅手段の光入力ポートと前記第3の光サーキュレータの光出力ポートとを結ぶ光導波路と、
前記第4の片方向光増幅手段の光入力ポートと前記第4の光サーキュレータの光出力ポートとを結ぶ光導波路と、
光波長チャンネルの集合L Oの要素 λ_i ($i=1, 2, \dots, N$)に対応する光クロスコネク用スイッチ回路S1-i、SP-iまたは光回路S3-iのいずれかの第1の光入力ポートと前記光波長台分波回路の波長台分波に関する集合A-1の波長チャンネル λ_i に対応する分波側の第1の光入出力ポートとをそれぞれ結ぶ光導波路と、
光クロスコネク用スイッチ回路S1-i、SP-iまたは光回路S3-iのいずれかの第2の光入力ポートと前記光波長台分波回路の波長台分波に関する集合A-2の波長チャンネル λ_i に対応する分波側の第2の光入力ポートとをそれぞれ結ぶ光導波路と、
光クロスコネク用スイッチ回路S1-i、SP-iまたは光回路S3-iのいずれかの第3の光入力ポートと

前記光波長台分岐回路の波長台分岐に関する集合A-3の波長チャンネル入₁に対応する分岐側の第3の光入出力ポートとをそれぞれ総て結ぶ光導波路と、
光クロスコネク用スイッチ回路S1-i、SP-iまたは光回路S3-iのいずれかの第4の光入力ポートと前記光波長台分岐回路の波長台分岐に関する集合A-4の波長チャンネル入₁に対応する分岐側の第4の光入出力ポートとをそれぞれ総て結ぶ光導波路と、
光クロスコネク用スイッチ回路S1-i、SP-iまたは光回路S3-iのいずれかの第1の光出力ポートと前記光波長台分岐回路の波長台分岐に関する集合A-5の波長チャンネル入₁に対応する分岐側の第5の光入出力ポートとをそれぞれ総て結ぶ光導波路と、
光クロスコネク用スイッチ回路S1-i、SP-iまたは光回路S3-iのいずれかの第2の光出力ポートと前記光波長台分岐回路の波長台分岐に関する集合A-6の波長チャンネル入₁に対応する分岐側の第6の光入出力ポートとをそれぞれ総て結ぶ光導波路と、
光クロスコネク用スイッチ回路S1-i、SP-iまたは光回路S3-iのいずれかの第3の光出力ポートと前記光波長台分岐回路の波長台分岐に関する集合A-7の波長チャンネル入₁に対応する分岐側の第7の光入出力ポートとをそれぞれ総て結ぶ光導波路と、
光クロスコネク用スイッチ回路S1-i、SP-iまたは光回路S3-iのいずれかの第4の光出力ポートと前記光波長台分岐回路の波長台分岐に関する集合A-8の波長チャンネル入₁に対応する分岐側の第8の光入出力ポートとをそれぞれ総て結ぶ光導波路とを有することを特徴とする光バス・アレンジ用光回路。

【請求項6】 前記光クロスコネク用スイッチ回路S1-jは、

1または複数のPLC基板上に形成され、
第1および第2の2つの光入力ポートと第1および第2の2つの光出力ポートを備え、

第1の光入力ポートと第1の光出力ポートとの間および第2の光入力ポートと第2の光出力ポートとの間で信号光を透過させ、かつ第1の光入力ポートと第1の光出力ポートとの間および第2の光入力ポートと第2の光出力ポートとの間を除く全ての光入出力ポート間で信号光を遮断するか、または第1の光入力ポートと第2の光出力ポートとの間および第2の光入力ポートと第1の光出力ポートとの間で信号光を透過させ、かつ第1の光入力ポートと第2の光出力ポートとの間および第2の光入力ポートと第1の光出力ポートとの間を除く全ての光入出力ポート間で信号光を遮断するかを任意に選択することができる2×2クロス・バード作光スイッチ回路CS-K (K=1)と。

各々が第1および第2の2つの分岐側光入出力ポートおよび1つの合波側光入出力ポートを備え、

第1の分岐側光入出力ポートと第1の合波側光入出力ポ

ートとの間で信号光を透過させ、かつ第1の分岐側光入出力ポートと第1の合波側光入出力ポートとの間を除く全ての光入出力ポート間で信号光を遮断するか、または第2の分岐側光入出力ポートと第1の合波側光入出力ポートとの間で信号光を透過させ、かつ第2の分岐側光入出力ポートと第1の合波側光入出力ポートとの間を除く全ての光入出力ポート間で信号光を遮断するかを任意に選択することができる第1乃至第4の4つの2×1透過結合ポート選択光スイッチ回路SS-i (i=1, 2, 3, 4)と、

光クロスコネク用スイッチ回路S1-jの第1の光入力ポートと何れかの2×1透過結合ポート選択光スイッチ回路SS-1の第1の分岐側光入出力ポートとを結ぶ光導波路と、

光クロスコネク用スイッチ回路S1-jの第2の光入力ポートと前記2×1透過結合ポート選択光スイッチ回路SS-1の第2の分岐側光入出力ポートとを結ぶ光導波路と、

光クロスコネク用スイッチ回路S1-jの第3の光入力ポートと前記2×1透過結合ポート選択光スイッチ回路SS-1を除く何れかの2×1透過結合ポート選択光スイッチ回路SS-2の第2の分岐側光入出力ポートとを結ぶ光導波路と、

光クロスコネク用スイッチ回路S1-jの第4の光入力ポートと前記2×1透過結合ポート選択光スイッチ回路SS-2の第1の分岐側光入出力ポートとを結ぶ光導波路と、

光クロスコネク用スイッチ回路S1-jの第1の光出力ポートと前記2×1透過結合ポート選択光スイッチ回路SS-1およびSS-2を除く何れかの2×1透過結合ポート選択光スイッチ回路SS-3の第2の分岐側光入出力ポートとを結ぶ光導波路と、

光クロスコネク用スイッチ回路S1-jの第2の光出力ポートと前記2×1透過結合ポート選択光スイッチ回路SS-3の第1の分岐側光入出力ポートとを結ぶ光導波路と、

光クロスコネク用スイッチ回路S1-jの第3の光出力ポートと前記2×1透過結合ポート選択光スイッチ回路SS-1、SS-2、およびSS-2を除く何れかの2×1透過結合ポート選択光スイッチ回路SS-4の第1の分岐側光入出力ポートとを結ぶ光導波路と、

光クロスコネク用スイッチ回路S1-jの第4の光出力ポートと前記2×1透過結合ポート選択光スイッチ回路SS-4の第2の分岐側光入出力ポートとを結ぶ光導波路と、

前記2×1透過結合ポート選択光スイッチ回路SS-1の第1の合波側光入出力ポートと前記2×2クロス・バード作光スイッチ回路CS-1の第1の光入力ポートとを結ぶ光導波路と、

前記2×1透過結合ポート選択光スイッチ回路SS-2

の第1の合波側光入出力ポートと前記2×2クロス・バー動作光スイッチ回路CS-1の第2の光入力ポートとを結ぶ光導波路と、

前記2×1透過結合ポート選択光スイッチ回路SS-3の第1の合波側光出力ポートと前記2×2クロス・バー動作光スイッチ回路CS-1の第1の光出力ポートとを結ぶ光導波路と、

前記2×1透過結合ポート選択光スイッチ回路SS-4の第1の合波側光入出力ポートと前記2×2クロス・バー動作光スイッチ回路CS-1の第2の光出力ポートとを結ぶ光導波路とを有することを特徴とする請求項5記載の光バス・アレンジ用光回路。

【請求項7】 前記光クロスコネク用スイッチSP-jは、

1または複数のPLC基板上に作成され、
各々が第1および第2の2つの光入力ポートと第1および第2の2つの光出力ポートとを備え

第1の光入力ポートと第1の光出力ポートとの間および第2の光入力ポートと第2の光出力ポートとの間で信号光を透過させ、かつ第1の光入力ポートと第1の光出力ポートとの間および第2の光入力ポートと第2の光出力ポートとの間を除く全ての光入出力ポート間で信号光を遮断するか、または

第1の光入力ポートと第2の光出力ポートとの間および第2の光入力ポートと第1の光出力ポートとの間で信号光を透過させ、かつ第1の光入力ポートと第2の光出力ポートとの間および第2の光入力ポートと第1の光出力ポートとの間を除く全ての光入出力ポート間で信号光を遮断するかを任意に選択することができる第1乃至第4の4つの2×2クロス・バー動作光スイッチ回路CS-k (k=1, 2, 3, 4) と、

各々が第1および第2の2つの分波側光入出力ポートおよび1つの合波側光入出力ポートを備え、

第1の分波側光入出力ポートと第1の合波側光入出力ポートとの間で信号光を透過させ、かつ第1の分波側光入出力ポートと第1の合波側光入出力ポートとの間を除く全ての光入出力ポート間で信号光を遮断するか、または第2の分波側光入出力ポートと第1の合波側光入出力ポートとの間で信号光を透過させ、かつ第2の分波側光入出力ポートと第1の合波側光入出力ポートとの間を除く全ての光入出力ポート間で信号光を遮断するかを任意に選択することができる第1乃至第4の4つの2×1透過結合ポート選択光スイッチ回路SS-i (i=1, 2, 3, 4) と、

光クロスコネク用スイッチSP-jの第1の光入力ポートと何れかの2×2クロス・バー動作光スイッチ回路CS-1の第2の光入力ポートとを結ぶ光導波路と、
光クロスコネク用スイッチSP-jの第2の光入力ポートと前記2×2クロス・バー動作光スイッチ回路CS-1の第1の光入力ポートとを結ぶ光導波路と、

光クロスコネク用スイッチSP-jの第3の光入力ポートと前記2×2クロス・バー動作光スイッチ回路CS-1を除く何れかの2×2クロス・バー動作光スイッチ回路CS-2の第1の光入力ポートとを結ぶ光導波路と、

光クロスコネク用スイッチSP-jの第4の光入力ポートと前記2×2クロス・バー動作光スイッチ回路CS-2の第2の光入力ポートとを結ぶ光導波路と、

光クロスコネク用スイッチSP-jの第1の光出力ポートと2×2クロス・バー動作光スイッチ回路CS-1、CS-2を除く何れかの2×2クロス・バー動作光スイッチ回路CS-3の第2の光出力ポートとを結ぶ光導波路と、

光クロスコネク用スイッチSP-jの第2の光出力ポートと2×2クロス・バー動作光スイッチ回路CS-3の第1の光出力ポートとを結ぶ光導波路と、

光クロスコネク用スイッチSP-jの第3の光出力ポートと2×2クロス・バー動作光スイッチ回路CS-1、CS-2、CS-3を除く何れかの2×2クロス・バー動作光スイッチ回路CS-4の第1の光出力ポートとを結ぶ光導波路と、

光クロスコネク用スイッチSP-jの第4の光出力ポートと2×2クロス・バー動作光スイッチ回路CS-4の第2の光出力ポートとを結ぶ光導波路と、

2×2クロス・バー動作光スイッチ回路CS-1の第1の光出力ポートと何れかの2×1透過結合ポート選択光スイッチ回路SS-1の第2の分波側光入出力ポートとを結ぶ光導波路と、

2×2クロス・バー動作光スイッチ回路CS-2の第1の光出力ポートと前記2×1透過結合ポート選択光スイッチ回路SS-1の第1の分波側光入出力ポートとを結ぶ光導波路と、

2×2クロス・バー動作光スイッチ回路CS-2の第2の光出力ポートと2×1透過結合ポート選択光スイッチ回路SS-1を除く何れかの2×1透過結合ポート選択光スイッチ回路SS-2の第1の分波側光入出力ポートとを結ぶ光導波路と、

2×2クロス・バー動作光スイッチ回路CS-1の第2の光出力ポートと前記2×1透過結合ポート選択光スイッチ回路SS-2の第2の分波側光入出力ポートとを結ぶ光導波路と、

2×2クロス・バー動作光スイッチ回路CS-3の第1の光入力ポートと2×1透過結合ポート選択光スイッチ回路SS-1、SS-2を除く何れかの2×1透過結合ポート選択光スイッチ回路SS-3の第1の分波側光入出力ポートとを結ぶ光導波路と、

2×2クロス・バー動作光スイッチ回路CS-4の第1の光入力ポートと2×1透過結合ポート選択光スイッチ回路SS-3の第1の分波側光入出力ポートとを結ぶ光導波路と、

2×2クロス・バー動作光スイッチ回路CS-4の第2の光出力ポートと2×1透過結合ポート選択光スイッチ回路SS-3の第1の分波側光入出力ポートとを結ぶ光導波路と、

2×2クロス・バー動作光スイッチ回路CS-4の第1の光入力ポートと2×1透過結合ポート選択光スイッチ回路SS-3の第1の分波側光入出力ポートとを結ぶ光導波路と、

2×2クロス・バー動作光スイッチ回路CS-4の第2の光出力ポートと2×1透過結合ポート選択光スイッチ回路SS-3の第1の分波側光入出力ポートとを結ぶ光導波路と、

2×2クロス・バー動作光スイッチ回路CS-4の第1の光入力ポートと2×1透過結合ポート選択光スイッチ回路SS-3の第1の分波側光入出力ポートとを結ぶ光導波路と、

2×2クロス・バー動作光スイッチ回路CS-4の第2の光出力ポートと2×1透過結合ポート選択光スイッチ回路SS-3の第1の分波側光入出力ポートとを結ぶ光導波路と、

2×2クロス・バー動作光スイッチ回路CS-4の第1の光入力ポートと2×1透過結合ポート選択光スイッチ回路SS-3の第1の分波側光入出力ポートとを結ぶ光導波路と、

2×2クロス・バー動作光スイッチ回路CS-4の第2の光出力ポートと2×1透過結合ポート選択光スイッチ回路SS-3の第1の分波側光入出力ポートとを結ぶ光導波路と、

2×2クロス・バー動作光スイッチ回路CS-4の第1の光入力ポートと2×1透過結合ポート選択光スイッチ回路SS-3の第1の分波側光入出力ポートとを結ぶ光導波路と、

2×2クロス・バー動作光スイッチ回路CS-4の第2の光出力ポートと2×1透過結合ポート選択光スイッチ回路SS-3の第1の分波側光入出力ポートとを結ぶ光導波路と、

2×2クロス・バー動作光スイッチ回路CS-4の第1の光入力ポートと2×1透過結合ポート選択光スイッチ回路SS-3の第1の分波側光入出力ポートとを結ぶ光導波路と、

2×2クロス・バー動作光スイッチ回路CS-4の第2の光入力ポートと2×1透過結合ポート選択光スイッチ回路SS-1、SS-2、SS-3を除く何れかの2×1透過結合ポート選択光スイッチ回路SS-4の第2の分波側光入出力ポートとを結ぶ光導波路と、
2×2クロス・バー動作光スイッチ回路CS-3の第2の光入力ポートと2×1透過結合ポート選択光スイッチ回路SS-4の第1の分波側光入出力ポートとを結ぶ光導波路と、

2×1透過結合ポート選択光スイッチ回路SS-1の第1の合波側光入出力ポートと2×1透過結合ポート選択光スイッチ回路SS-3の第1の合波側光入出力ポートとを結ぶ光導波路と、

2×1透過結合ポート選択光スイッチ回路SS-2の第1の合波側光入出力ポートと2×1透過結合ポート選択光スイッチ回路SS-4の第1の合波側光入出力ポートとを結ぶ光導波路とを有することを特徴とする請求項5記載の光バス・アレンジ用光回路。

【請求項8】 前記2×2クロス・バー動作光スイッチ回路CS-1は、マッハ・ツェンダ型平面導波路光TOスイッチ回路、またはダブルゲートマッハ・ツェンダ型平面導波路光TOスイッチ回路、またはマッハ・ツェンダ型平面導波路光LNスイッチ回路、またはダブルゲートマッハ・ツェンダ型平面導波路光LNスイッチ回路、または半導体光増幅器(SOA)型2×2光スイッチ回路で構成されることを特徴とする請求項6または7記載の光バス・アレンジ用光回路。

【請求項9】 前記2×1透過結合ポート選択光スイッチ回路SS-iは、マッハ・ツェンダ型平面導波路光TOスイッチ回路の4つの光入出力ポートのうち、何れか3つの光入出力ポートを用いて実現されたもの、またはダブルゲートマッハ・ツェンダ型平面導波路光TOスイッチ回路の4つの光入出力ポートのうち、何れか3つの光入出力ポートを用いて実現されたもの、またはダブルゲートマッハ・ツェンダ型平面導波路光TOスイッチ回路の構成における4つのマッハ・ツェンダ型平面導波路光TOスイッチ回路部とこれら4つのマッハ・ツェンダ型平面導波路光TOスイッチ回路部の光入出力ポート間を結ぶ光導波路のうち、何れか3つのマッハ・ツェンダ型平面導波路光TOスイッチ回路部とこれら3つのマッハ・ツェンダ型平面導波路光TOスイッチ回路部の光入出力ポート間を結ぶ光導波路のみから構成される2×1透過結合ポート選択光スイッチ回路、またはマッハ・ツェンダ型平面導波路光LNスイッチ回路の4つの光入出力ポートのうち、何れか3つの光入出力ポートを用いて実現されたもの、またはダブルゲートマッハ・ツェンダ型平面導波路光LNスイッチ回路の4つの光入出力ポートのうち、何れか3つの光入出力ポートを用いて実現されたもの、またはダブルゲートマッハ・ツェンダ型平面導波路光LNスイッチ回路の構成における4つのマッハ

・ツェンダ型平面導波路光LNスイッチ回路部とこれら4つのマッハ・ツェンダ型平面導波路光LNスイッチ回路部の光入出力ポート間を結ぶ光導波路のうち、何れか3つのマッハ・ツェンダ型平面導波路光LNスイッチ回路部とこれら3つのマッハ・ツェンダ型平面導波路光LNスイッチ回路部の光入出力ポート間を結ぶ光導波路のみから構成される2×1透過結合ポート選択光スイッチ回路で構成されることを特徴とする請求項6または7記載の光バス・アレンジ用光回路。

【請求項10】 前記光クロスコネク用スイッチ回路S1-jは、

1つのPLC基板平面上に全ての構成光回路が作成されており、

基板上面から見て、時計回りに光クロスコネク用スイッチ回路S1-jの第2の光出力ポート、第1の光出力ポート、第3の光出力ポート、第4の光出力ポート、第4の光入力ポート、第3の光入力ポート、第1の光入力ポート、第2の光入力ポートの順に各光入力・出力ポートが隣り合うように配置され、

2×2クロス・バー動作光スイッチ回路CS-k(k=1)の光入出力ポートが基板上面から見て、時計回りに第2の光入力ポート、第1の光入力ポート、第1の光出力ポート、第2の光出力ポートの順に隣り合うように配置され、

4つの2×1透過結合ポート選択光スイッチ回路SS-i(i=1, 2, 3, 4)の光入出力ポートが基板上面から見て、時計回りに第1の分波側光入出力ポート、第2の分波側光入出力ポート、第1の合波側光入出力ポートの順に隣り合うように配置され、

更に、各々の2×2クロス・バー動作光スイッチ回路および2×1透過結合ポート選択光スイッチ回路の間隔が適度にあたえられることにより、各々の2×2クロス・バー動作光スイッチ回路および2×1透過結合ポート選択光スイッチ回路の光入力ポート、光出力ポート間を結ぶ何れかの光導波路も交差しない配置になっていることを特徴とする請求項6記載の光バス・アレンジ用光回路。

【請求項11】 光クロスコネク用スイッチSP-jは、

1つのPLC基板平面上に全ての構成光回路が作成されており、

基板上面から見て、時計回りに光クロスコネク用スイッチSP-jの第2の光出力ポート、第1の光出力ポート、第3の光出力ポート、第4の光出力ポート、第4の光入力ポート、第3の光入力ポート、第1の光入力ポート、第2の光入力ポートの順に各光入力・出力ポートが隣り合うように配置され、

4つの2×2クロス・バー動作光スイッチ回路CS-k(k=1, 2, 3, 4)の光入出力ポートが基板上面から見て、時計回りに第2の光入力ポート、第1の光入力

ポート、第1の光出力ポート、第2の光出力ポートの順に隣り合うように配置され、

4つの2×1透過結合ポート選択光スイッチ回路SS-1 (i=1, 2, 3, 4)の光入出力ポートが基板上面から見て、時計回りに第1の分波側光入出力ポート、第2の分波側光入出力ポート、第1の合波側光入出力ポートの順に隣り合うように配置され、

更に、各々の2×2クロス・バー動作光スイッチ回路の間隔が適度にあたえられることにより、各々の2×2クロス・バー動作光スイッチ回路の光入力ポート、光出力ポート間を結ぶ何れかの光導波路において、2×2クロス・バー動作光スイッチ回路CS-1の第2の光出力ポートと2×1透過結合ポート選択光スイッチ回路SS-2の第2の分波側光入出力ポートとの間、2×2クロス・バー動作光スイッチ回路CS-2の第1の光出力ポートと2×1透過結合ポート選択光スイッチ回路SS-1の第1の分波側光入出力ポートとの間をそれぞれ結ぶ光導波路と、2×2クロス・バー動作光スイッチ回路CS-3の第2の光入力ポートと2×1透過結合ポート選択光スイッチ回路SS-4の第1の分波側光入出力ポートとの間および2×2クロス・バー動作光スイッチ回路CS-4の第1の光入力ポートと2×1透過結合ポート選択光スイッチ回路SS-3の第2の分波側光入出力ポートとの間をそれぞれ結ぶ光導波路との2組がそれぞれ所すず、計2ヶ所のみが交差し、それ以外の光入力ポート、光出力ポート間を結ぶ光導波路の交差がない配置となっていることを特徴とする請求項7記載の光バス・アレイ用光回路。

【請求項12】 前記光波長合成分波回路は、アレー導波路型平面光回路(AWG)であることを特徴とする請求項5記載の光バス・アレイ用光回路。

【請求項13】 波長合成分波に関する集合A-1, A-2, A-3, A-4を形成し、かつ互いに交差ししない光入出力用導波路を全て持つ1つのアレー導波路平面光回路WM-1と、

波長合成分波に関する集合A-5, A-6, A-7, A-8を形成し、かつ互いに交差ししない光入出力用導波路を全て持つ1つのアレー導波路平面光回路WM-2と、

各波長チャンネルにそれぞれ対応して個別に配置され、かつ波長チャンネル毎にそれらのいずれかが配置される4入力4出力光クロスコネク用スイッチ回路S1-j, SP-j, および光回路S3-jと、

前記アレー導波路平面光回路WM-1, WM-2の光入出力ポートおよび4入力4出力光クロスコネク用スイッチ回路S1-j, SP-j, および光回路S3-j (j=1, 2, ..., N)の光入力ポートおよび光出力ポートのそれぞれに対応するポート同士を結ぶ光導波路とで構成される光波長合成分波回路および光クロスコネク用スイッチ回路部で、

前記アレー導波路平面光回路WM-1の各々の集合の分

波側の光入出力導波路で任意の波長チャンネルλiに対応する光入出力ポートが時計回りまたは反時計回りの何れかの回りで第2, 第1, 第3, 第4の分波側光入出力ポート(A-I/O-d-2-i, A-I/O-d-1-i, A-I/O-d-3-i, A-I/O-d-4-i)の順番で並んでおり、かつこれらの順番に並んでいる光入出力ポートの間には、その他のすべての合波側の光入出力ポートおよび対応する波長チャンネルが異なる分波側の光入出力ポートが入り込まずに、対応する波長チャンネル毎に光入出力ポートがそれぞれ位置的に集団を成しており、

前記アレー導波路平面光回路WM-2の各々の集合の分波側の光入出力導波路で任意の波長チャンネルλiに対応する光入出力ポートが前記アレー導波路平面光回路WM-1において光入出力ポートが第2, 第1, 第3, 第4の分波側光入出力ポート(A-I/O-d-2-i, A-I/O-d-1-i, A-I/O-d-3-i, A-I/O-d-4-i)の順番となる回りととは逆回りに第6, 第5, 第7, 第8の分波側光入出力ポート(A-I/O-d-6-i, A-I/O-d-5-i, A-I/O-d-7-i, A-I/O-d-8-i)の順番で並んでおり、かつこれらの順番に並んでいる光入出力ポートの間には、その他のすべての合波側の光入出力ポートおよび対応する波長チャンネルが異なる分波側の光入出力ポートが入り込まずに、対応する波長チャンネル毎に光入出力ポートがそれぞれ位置的に集団を成しており、

更に分波側の波長チャンネル毎の光入出力ポートの集団同士の対応する波長チャンネルに關しての並びの順番と前記アレー導波路平面光回路WM-1の分波側の波長チャンネル毎の光入出力ポートの集団同士の対応する波長チャンネルに關しての並びの順番とが互いに逆回りで同じ順番となっており、

更に、各々の4入力4出力光クロスコネク用スイッチ回路S1-j, SP-j, および光回路S3-j (j=1, 2, ..., N)の光出力ポートの集団同士の対応する波長チャンネルに關しての並びの順番と前記アレー導波路平面光回路WM-1の分波側の波長チャンネル毎の光入出力ポートの集団同士の対応する波長チャンネルに關しての並びの順番とが互いに同じ回りで同じ順番となっており、

かつ各々の4入力4出力光クロスコネク用スイッチ回路S1-j, SP-j, および光回路S3-j (j=1, 2, ..., N)の光出力ポートの集団同士の対応する波長チャンネルに關しての並びの順番と前記アレー導波路平面光回路WM-1の分波側の波長チャンネル毎の光入出力ポートの集団同士の対応する波長チャンネルに關しての並びの順番とが互いに逆回りで同じ順番となっていることにより、

同一平面上でアレー導波路平面光回路WM-1, WM-

2と4入力4出力光クロスコネク用スイッチ回路S1-j, SP-j, および光回路S3-j (j=1, 2, ..., N) とを結ぶ光導波路同士で互いに交差するものが1つもないような回路の配置および構成であり、

アレー導波路平面光回路WM-1, WM-2および4入力4出力光クロスコネク用スイッチ回路S1-j, SP-j, および光回路S3-j (j=1, 2, ..., N) と、アレー導波路平面光回路WM-1, WM-2および4入力4出力光クロスコネク用スイッチ回路S1-j, SP-j, および光回路S3-j (j=1, 2, ..., N) 間をそれぞれ結ぶ光導波路とを同一平面基板上に作成するか、

または個別の作成された光波長台分波部の平面回路基板と光クロスコネク用スイッチ回路の平面回路基板とを突き合わせする形で各々の光入出力ポート同士を結合し、1つの平面状光回路を形成することを特徴とする請求項5記載の光バス・アレンジ用光回路。

【請求項14】 前記光サークキュレータにおいて、光入力ポートに入力された光は、光入出力ポートから出力され、光入出力ポートから入力された光は、光出力ポートから出力され、光入出力ポートから入力され光入力ポートから出力される光は、十分に抑圧され、光出力ポートから入力され、光入出力ポートから出力される光は、十分に抑圧され、光入出力ポートと光出力ポートとの間では光の入出力の向きに関わらず光が十分に抑圧されることを特徴とする請求項5記載の光バス・アレンジ用光回路。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】 本発明は、通信用光回路に有効な光バス・アレンジ用光回路に関する。

【0002】

【従来の技術】 従来の広く知られている光クロスコネク回路および光アド・ドロップ回路の構成例をそれぞれ図9および図10に示す。両図において、1-1, 1-2, 1-3, 1-4は光増幅器1-1, 1-2, 1-3, 1-4, 2-1, 2-2, 2-3, 2-4は光波長台分波部2-1, 2-2, 2-3, 2-4, 3-j (j=1, 2, ..., n) は2入力2出力クロス・バー動作光スイッチ回路3-j, 0-1, 0-3, 0-3-1~0-3-nは外部光入力ポート, 0-2, 0-4, 0-4-1~0-4-nは外部光出力ポートである。

【0003】 図9および図10において、光増幅器1-1, 1-2, 1-3, 1-4は、光伝送路の損失の補償、ならびに光クロスコネク回路と光アド・ドロップ回路自体の光増幅器を除く部分の損失の補償のために設けられている。各光増幅器1-1, 1-2, 1-3, 1-4の構成は、一般の伝送路上にはコネクタ接続箇所等の光信号の反射点が存在するので、これらの反射点からの反射光を遮断し安定して光増幅を行うために、図11

に示すように、光増幅器1-1-1の前後に所望の光伝送方向のみに信号光の伝播を制限する光アイソレータ1-i-2-1および1-i-2-2が設けられている。このため、波長多量信号を光増幅する場合にも、その伝播方向はすべて同一方向に制限されている。

【0004】 また、光増幅器1-1, 1-2, 1-3, 1-4の構成要素である光増幅部としては、一般に励起用半導体レーザによる双方向励起(図12a)、前方励起(図12b)、後方励起(図12c)の希土類添加光ファイバまたは半導体型の光増幅部(図12d)が使用されている。

【0005】 希土類添加光ファイバのホストには、通常は石英系ガラスが増幅波長帯域を拡大するためにZr系フッ化物ガラスおよびアルミド系ガラスが用いられている。また、添加希土類としては、 1.5×10^{-6} m帯用に 1.3×10^{-6} m帯用にPr³⁺が用いられている(山田他、1995秋季学会論文集C215, A. Mori et al. OFC97, PDP1参照)。

【0006】 なお、図12において、4は希土類添加ファイバ、5-1, 5-2は励起用レーザ、6-1, 6-2は光アイソレータ、7-1, 7-2は波長台分波カプラー、8は平面型導波路基板である。

【0007】 まず最初に、図9に示す光クロスコネク回路の動作について説明する。図9に示す光クロスコネク回路において、外部入力ポート0-1, 0-3から入力された波長多量信号光は、それぞれ光増幅器1-1, 1-3で光増幅され、それから光波長台分波部2-1, 2-3で各波長チャンネルの信号光毎に分波される。光波長台分波部において波長チャンネル毎に分波された信号光は、それぞれ同じ波長チャンネルに対応する信号光のペア毎に互いに異なる2入力2出力クロス・バー動作光スイッチ回路3-1~3-nに入力され、それぞれ個別にクロス・バーの出力ポートの切り替え選択が行われ出力される。

【0008】 この出力された信号光は、それぞれ波長チャンネルに重複が生じないような2つの信号光の集まり毎に光波長台分波部2-2, 2-4で合波され、後段の光増幅器1-2, 1-4で光増幅された後、外部出力ポート0-2, 0-4から出力される。

【0009】 上述した光クロスコネク回路における動作により、光伝送路の損失補償および2つの波長多量信号光の波長チャンネルの組み替え、すなわち光クロスコネクが実現される。

【0010】 次に、図10に示す光アド・ドロップ回路の動作について説明する。図10に示す光アド・ドロップ回路において、外部入力ポート0-1から入力された波長多量信号光は、光増幅器1-1で光増幅され、それから光波長台分波部2-1で各波長チャンネルの信号光毎に分波される。光波長台分波部において波長チャンネル毎に分波された信号光および各波長チャンネル毎に設

けられた外部入力ポート0-3-1~0-3-nから入力されるアド(ADD)入力信号光は、それぞれ同じ波長チャンネルに対応する信号光のペア毎に互いに異なる2入力2出力クロス・バー動作光スイッチ回路3-1~3-nに入力され、それぞれ個別にクロス・バーの出力ポートの切り替え選択が行われ出力される。

【0011】この出力された信号光は、それぞれ波長チャンネルに重複が生じないような2つの信号光の集まり毎に一方を光波長合成分波部2-2で合波され、他方を各波長チャンネル毎に設けられた外部出力ポート0-4-1~0-4-nからドロップ(DROP)出力信号光として出力する。光波長合成分波部2-2で合波された波長多重信号光は、後段の光増幅器1-2で光増幅された後、外部出力ポート0-2から出力される。

【0012】上述した光アド・ドロップ回路の動作により、光伝送路の損失補償と波長多重信号光の波長チャンネル毎の信号光のアド・ドロップが実現される。

【0013】

【発明が解決しようとする課題】上述した従来の光クロスコネクタ回路および光アド・ドロップ回路は、光伝送路および光回路自体の損失を補償するために片方向光増幅器を使用しているため、波長多重信号光の伝搬方向に関しては全て予め決めたある同じ方向に固定となってしまう。その結果クロス・バー型の経路の2つの状態の切り替えのみに機能が制限されてしまうという問題がある。

【0014】本発明は、上記に鑑みてなされたもので、その目的とするところは、光ファイバ中をそれぞれの波長チャンネル毎に上りおよび下り方向に関して任意の伝搬方向に伝搬され、かつそれぞれの波長チャンネル毎に必要なに応じて各々の伝搬方向を上りから下りまたは下りから上りに切り替えるといった動的な変化に伴う2つのストリームに属する波長多重信号光をその時々に応じて信号光の伝搬方向へのアイソレーションを確保しつつ光増幅し、かつ各波長チャンネル毎に光クロスコネクタを行うことにより実現される図6に示す8通りの光伝搬増幅状態を実現するとともに、各波長チャンネル毎に4つの信号光入出力ポートに対してそれぞれ重複しない範囲で任意に入出力ポートを選択して信号光を入出力させ、2つの信号光ストリームを伝搬増幅させるすべての組合せである図7に示す12通りの光伝搬増幅状態の実現を達成し得る光バス・アレンジ用光回路を提供することにある。

【0015】

【課題を解決するための手段】上記目的を達成するため、請求項1記載の本発明は、少なくとも4つの外部光入出力ポートを有する光バス・アレンジ用光回路であって、前記外部光入出力ポートと接続される入出力ポートと入力ポートおよび出力ポートとをそれぞれ有する4つの光サーキュレータと、これら光サーキュレータの出力

ポートからの信号光をそれぞれ入力して増幅する4つの片方向光増幅手段と、これら4つの片方向光増幅手段からそれぞれ出力される信号光を入力して、該信号光の前記光サーキュレータの入力ポートへの出力を制御する光制御手段とを有することを要旨とする。

【0016】また、請求項2記載の本発明は、請求項1記載の本発明において、光制御手段が、2つの光波長合成分波回路と、複数の光クロスコネクタアドドロップスイッチとからなることを要旨とする。

【0017】また、請求項3記載の本発明は、請求項2記載の本発明において、前記光クロスコネクタアドドロップスイッチが、一方の側の前記光波長合成分波回路から入力した複数の光信号を適宜選択して出力する透過結合ポート選択光スイッチと、この透過結合ポート選択光スイッチからの光信号を入力して適宜出力先ポートを変更して出力する出力クロスバー動作光スイッチと、この出力クロスバー動作光スイッチからの光信号を、他方の側の前記光波長合成分波回路に接続される出力先ポートを適宜選択して出力する透過結合ポート選択光スイッチとにより構成されることを要旨とする。

【0018】また、請求項4記載の本発明は、請求項2記載の本発明において、前記光クロスコネクタアドドロップスイッチが、一方の側の前記光波長合成分波回路から入力した複数の光信号を適宜出力先ポートを変更して出力する出力クロスバー動作光スイッチと、この出力クロスバー動作光スイッチから入力した複数の光信号を適宜選択して出力する透過結合ポート選択光スイッチと、この透過結合ポート選択光スイッチから入力した光信号を適宜出力先ポートを選択して出力する透過結合ポート選択光スイッチと、この透過結合ポート選択光スイッチからの光信号を、他方の側の前記光波長合成分波回路に接続される出力先ポートを適宜選択して出力する出力クロスバー動作光スイッチにより構成されることを要旨とする。

【0019】請求項5記載の本発明は、第1乃至第4の外部光入出力ポートのそれぞれが接続される光入出力ポート、光入力ポート、および光出力ポートをそれぞれが有する第1乃至第4の光サーキュレータと、前記第1乃至第4の光サーキュレータのそれぞれの光入力ポートが1対1に対応して接続される第1の4つの光入出力ポート、および該第1の4つの光入出力ポートとは異なる第2の4つの光入出力ポートを有する1または複数の光波長合成分波回路と、前記第1乃至第4の光サーキュレータのそれぞれの光出力ポートと前記光波長合成分波回路の第2の4つの光入出力ポートで第1乃至第4の光サーキュレータのそれぞれの光出力ポートに1対1に対応する前記光波長合成分波回路の第2の4つの光入出力ポートとの間に接続され、第1乃至第4の光サーキュレータのそれぞれの光出力ポートから前記光波長合成分波回路の第2の4つの光入出力ポートに向かう方向に伝搬する光信号を

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の光入出力ポートの集合A-1、A-2、A-3、A-4、A-5、A-6以外の何れかの集合A-7の要素である合波側の第7の入出力ポートと第3の光サーキュレータの光入力ポートとを結ぶ光導波路と、光波長合成分波回路の光入出力ポートの集合A-1、A-2、A-3、A-4、A-5、A-6、A-7以外の何れかの集合A-8の要素である台波側の第8の入出力ポートと第4の光サーキュレータの光入力ポートとを結ぶ光導波路と、前記第1の片方向光増幅手段の光入力ポートと前記第1の光サーキュレータの光出力ポートとを結ぶ光導波路と、前記第2の片方向光増幅手段の光入力ポートと前記第2の光サーキュレータの光出力ポートとを結ぶ光導波路と、前記第3の片方向光増幅手段の光入力ポートと前記第3の光サーキュレータの光出力ポートとを結ぶ光導波路と、前記第4の片方向光増幅手段の光入力ポートと前記第4の光サーキュレータの光出力ポートとを結ぶ光導波路と、光波長チャンネルの集合Iの要素 λ_i ($i=1, 2, \dots, N$)に対応する光クロスコネク用スイッチ回路S1-i、SP-iまたは光回路S3-iのいずれかの第1の光入力ポートと前記光波長合成分波回路の波長合成分波に関する集合A-1の波長チャンネル λ_i に対応する分波側の第1の光入出力ポートとをそれぞれ結ぶ光導波路と、光クロスコネク用スイッチ回路S1-i、SP-iまたは光回路S3-iのいずれかの第2の光入力ポートと前記光波長合成分波回路の波長合成分波に関する集合A-2の波長チャンネル λ_i に対応する分波側の第2の光入出力ポートとをそれぞれ結ぶ光導波路と、光クロスコネク用スイッチ回路S1-i、SP-iまたは光回路S3-iのいずれかの第3の光入力ポートと前記光波長合成分波回路の波長合成分波に関する集合A-3の波長チャンネル λ_i に対応する分波側の第3の光入出力ポートとをそれぞれ結ぶ光導波路と、光クロスコネク用スイッチ回路S1-i、SP-iまたは光回路S3-iのいずれかの第4の光入力ポートと前記光波長合成分波回路の波長合成分波に関する集合A-4の波長チャンネル λ_i に対応する分波側の第4の光入出力ポートとをそれぞれ結ぶ光導波路と、光クロスコネク用スイッチ回路S1-i、SP-iまたは光回路S3-iのいずれかの第1の光出力ポートと前記光波長合成分波回路の波長合成分波に関する集合A-5の波長チャンネル λ_i に対応する分波側の第5の光入出力ポートとをそれぞれ結ぶ光導波路と、光クロスコネク用スイッチ回路S1-i、SP-iまたは光回路S3-iのいずれかの第2の光出力ポートと前記光波長合成分波回路の波長合成分波に関する集合A-6の波長チャンネル λ_i に対応する分波側の第6の光入出力ポートとをそれぞれ結ぶ光導波路と、光クロスコネク用スイッチ回路S1-i、SP-iまたは光回路S3-iのいずれかの第3の光出力ポートと前記光波長合成分波回路の波長合成分波に関する集合A-7の波長チャンネル λ_i に対応する分波

側の第7の光入出力ポートとをそれぞれ結ぶ光導波路と、光クロスコネク用スイッチ回路S1-i、SP-iまたは光回路S3-iのいずれかの第4の光出力ポートと前記光波長合成分波回路の波長合成分波に関する集合A-8の波長チャンネル λ_i に対応する分波側の第8の光入出力ポートとをそれぞれ結ぶ光導波路とを有することを要旨とする。

【0020】請求項5記載の本発明にあっては、各光入力ポートがそれぞれ外部光入出力ポートI/O-1、2、3、4に接続された第1乃至第4の光サーキュレータ、1または複数の光波長合成分波回路、および第1乃至第4の4つの片方向光増幅手段を有し、外部光入出力ポートI/O-1、2、3、4の間において図7に示す8通りの光伝搬増幅状態および図8に示す12通りの光伝搬増幅状態を実現し得る。

【0021】また、本発明の請求項6記載の本発明は、請求項5記載の本発明において、前記光クロスコネク用スイッチ回路S1-jが、1または複数のPLC基板上に形成され、第1および第2の2つの光入力ポートと第1および第2の2つの光出力ポートを備え、第1の光入力ポートと第1の光出力ポートとの間および第2の光入力ポートと第2の光出力ポートとの間で信号光を透過させ、かつ第1の光入力ポートと第1の光出力ポートとの間および第2の光入力ポートと第2の光出力ポートとの間を除く全ての光入出力ポート間で信号光を遮断するか、または第1の光入力ポートと第2の光出力ポートとの間および第2の光入力ポートと第1の光出力ポートとの間で信号光を透過させ、かつ第1の光入力ポートと第2の光出力ポートとの間を除く全ての光入出力ポート間で信号光を遮断するかを任意に選択することができる2×2クロス・バー動作光スイッチ回路CS-k ($k=1$)と、各々が第1および第2の2つの分波側光入出力ポートおよび1つの台波側光入出力ポートを備え、第1の分波側光入出力ポートと第1の台波側光入出力ポートとの間で信号光を透過させ、かつ第1の分波側光入出力ポートと第1の合波側光入出力ポートとの間を除く全ての光入出力ポート間で信号光を遮断するか、または第2の分波側光入出力ポートと第1の台波側光入出力ポートとの間で信号光を透過させ、かつ第2の分波側光入出力ポートと第1の合波側光入出力ポートとの間を除く全ての光入出力ポート間で信号光を遮断するかを任意に選択することができる第1乃至第4の4つの2×1透過結合ポート選択光スイッチ回路SS-i ($i=1, 2, 3, 4$)と、光クロスコネク用スイッチ回路S1-jの第1の光入力ポートと何れかの2×1透過結合ポート選択光スイッチ回路SS-1の第1の分波側光入出力ポートとを結ぶ光導波路と、光クロスコネク用スイッチ回路S1-jの第2の光入力ポートと前記2×1透過結合ポート選択光スイッチ回路SS-1の第2の分波側光入出

【００２２】請求項６記載の本発明においては、光クロスコネクタ用スイッチ回路Ｓ１～ｊでは、第１の光入力ポートと第２の光出力ポートとの間および第３の光入力ポートと第４の光出力ポートとの間で信号光を透過させ、かつ第１の光入力ポートと第２の光出力ポートとの間および第３の光入力ポートと第４の光出力ポートとの間を除く全ての光入力ポートと光出力ポートとの間で信号光を遮断するか、または第１の光入力ポートと第２の光出力ポートとの間および第４の光入力ポートと第３の光出力ポートとの間で信号光を透過させ、かつ第１の光入力ポートと第２の光出力ポートとの間および第４の光入力ポートと第３の光出力ポートとの間を除く全ての光

【００２３】更に、請求項７記載の本発明は、請求項５記載の本発明において、前記光クロスコネクト用スイッチＳＰ－ｊが、１または複数のＰＬＣ基板上に作成され、各々が第１および第２の２つの光入力ポートと第１および第２の２つの光出力ポートとを備え、第１の光入力ポートと第１の光出力ポートとの間および第２の光入力ポートと第２の光出力ポートとの間で信号光を透過させ、かつ第１の光入力ポートと第１の光出力ポートとの間および第２の光入力ポートと第２の光出力ポートとの間を除く全ての光入出力ポート間で信号光を遮断するか、または第１の光入力ポートと第２の光出力ポートとの間および第２の光入力ポートと第１の光出力ポートとの間で信号光を透過させ、かつ第１の光入力ポートと第２の光出力ポートとの間および第２の光入力ポートと第

1の光出力ポートとの間を除く全ての光入出力ポート間で信号光を遮断するかを任意に選択することができる第1乃至第4の4つの2×2クロス・バー動作光スイッチ回路CS-k (k=1, 2, 3, 4)と、各々が第1および第2の2つの分波側光入出力ポートおよび1つの合波側光入出力ポートを備え、第1の分波側光入出力ポートと第1の合波側光入出力ポートとの間で信号光を透過させ、かつ第1の分波側光入出力ポートと第1の合波側光入出力ポートとの間を除く全ての光入出力ポート間で信号光を遮断するか、または第2の分波側光入出力ポートと第1の合波側光入出力ポートとの間で信号光を透過させ、かつ第2の分波側光入出力ポートと第1の合波側光入出力ポートとの間を除く全ての光入出力ポート間で信号光を遮断するかを任意に選択することができる第1乃至第4の4つの2×1透過結合ポート選択光スイッチ回路SS-1 (i=1, 2, 3, 4)と、光クロスコネク用スイッチSP-jの第1の光入力ポートと何れかの2×2クロス・バー動作光スイッチ回路CS-1の第2の光入力ポートとを結ぶ光導波路と、光クロスコネク用スイッチSP-jの第2の光入力ポートと前記2×2クロス・バー動作光スイッチ回路CS-1の第1の光入力ポートとを結ぶ光導波路と、光クロスコネク用スイッチSP-jの第3の光入力ポートと前記2×2クロス・バー動作光スイッチ回路CS-1を除く何れかの2×2クロス・バー動作光スイッチ回路CS-2の第1の光入力ポートとを結ぶ光導波路と、光クロスコネク用スイッチSP-jの第4の光入力ポートと前記2×2クロス・バー動作光スイッチ回路CS-2の第2の光入力ポートとを結ぶ光導波路と、光クロスコネク用スイッチSP-jの第1の光出力ポートと2×2クロス・バー動作光スイッチ回路CS-1、CS-2を除く何れかの2×2クロス・バー動作光スイッチ回路CS-3の第2の光出力ポートとを結ぶ光導波路と、光クロスコネク用スイッチSP-jの第2の光出力ポートと2×2クロス・バー動作光スイッチ回路CS-3の第1の光出力ポートとを結ぶ光導波路と、光クロスコネク用スイッチSP-jの第3の光出力ポートと2×2クロス・バー動作光スイッチ回路CS-1、CS-2、CS-3を除く何れかの2×2クロス・バー動作光スイッチ回路CS-4の第1の光出力ポートとを結ぶ光導波路と、光クロスコネク用スイッチSP-jの第4の光出力ポートと2×2クロス・バー動作光スイッチ回路CS-4の第2の光出力ポートとを結ぶ光導波路と、2×2クロス・バー動作光スイッチ回路CS-1の第1の光出力ポートと何れかの2×1透過結合ポート選択光スイッチ回路SS-1の第2の分波側光入出力ポートとを結ぶ光導波路と、2×2クロス・バー動作光スイッチ回路CS-2の第1の光出力ポートと前記2×1透過結合ポート選択光スイッチ回路SS-1の第1の分波側光入出力ポートとを結ぶ光導波路と、2×2クロス・バー動作光スイッチ回路CS-2の第2の光出力ポートと前記2×1透過結合ポート選択光スイッチ回路SS-2の第1の分波側光入出力ポートとを結ぶ光導波路と、2×2クロス・バー動作光スイッチ回路CS-3の第1の光出力ポートと前記2×1透過結合ポート選択光スイッチ回路SS-2の第2の分波側光入出力ポートとを結ぶ光導波路と、2×2クロス・バー動作光スイッチ回路CS-4の第1の光出力ポートと2×1透過結合ポート選択光スイッチ回路SS-3の第1の分波側光入出力ポートとを結ぶ光導波路と、2×2クロス・バー動作光スイッチ回路CS-4の第2の光出力ポートと2×1透過結合ポート選択光スイッチ回路SS-3の第2の分波側光入出力ポートとを結ぶ光導波路と、2×1透過結合ポート選択光スイッチ回路SS-4の第1の合波側光入出力ポートと2×1透過結合ポート選択光スイッチ回路SS-1の第1の合波側光入出力ポートとを結ぶ光導波路と、2×1透過結合ポート選択光スイッチ回路SS-2の第1の合波側光入出力ポートと2×1透過結合ポート選択光スイッチ回路SS-4の第1の合波側光入出力ポートとを結ぶ光導波路とを有することを要旨とする。

CS-2の第2の光出力ポートと2×1透過結合ポート選択光スイッチ回路SS-1を除く何れかの2×1透過結合ポート選択光スイッチ回路SS-2の第1の分波側光入出力ポートとを結ぶ光導波路と、2×2クロス・バー動作光スイッチ回路CS-1の第2の光出力ポートと前記2×1透過結合ポート選択光スイッチ回路SS-2の第2の分波側光入出力ポートとを結ぶ光導波路と、2×2クロス・バー動作光スイッチ回路CS-3の第1の光入力ポートと2×1透過結合ポート選択光スイッチ回路SS-3の第1の分波側光入出力ポートとを結ぶ光導波路と、2×2クロス・バー動作光スイッチ回路CS-4の第2の光入力ポートと2×1透過結合ポート選択光スイッチ回路SS-3の第2の分波側光入出力ポートとを結ぶ光導波路と、2×1透過結合ポート選択光スイッチ回路SS-4の第1の合波側光入出力ポートと2×1透過結合ポート選択光スイッチ回路SS-1の第1の合波側光入出力ポートとを結ぶ光導波路と、2×1透過結合ポート選択光スイッチ回路SS-2の第1の合波側光入出力ポートと2×1透過結合ポート選択光スイッチ回路SS-4の第1の合波側光入出力ポートとを結ぶ光導波路とを有することを要旨とする。

【0024】請求項7記載の本発明にあっては、光クロスコネク用スイッチSP-jでは、第1の光入力ポートと第2の光出力ポートとの間および第3の光入力ポートと第4の光出力ポートとの間で信号光を透過させ、かつ第1の光入力ポートと第2の光出力ポートとの間および第3の光入力ポートと第4の光出力ポートとの間を除く全ての光入力ポートと光出力ポートとの間で信号光を遮断するか、または第1の光入力ポートと第2の光出力ポートとの間および第4の光入力ポートと第3の光出力ポートとの間で信号光を透過させ、かつ第1の光入力ポートと第2の光出力ポートとの間および第4の光入力ポートと第3の光出力ポートとの間を除く全ての光入力ポートと光出力ポートとの間で信号光を遮断するか、または第1の光入力ポートと第4の光出力ポートとの間および第3の光入力ポートと第2の光出力ポートとの間で信号光を透過させ、かつ第1の光入力ポートと第4の光出力ポートとの間および第3の光入力ポートと第2の光出力ポートとの間を除く全ての光入力ポートと光出力ポートとの間で信号光を遮断するか、または第1の光入力ポ

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【0025】請求項8記載の本発明は、請求項6または7記載の本発明において、前記2×2クロス・バー動作光スイッチ回路CS-1が、マッハ・ツェンダ型平面導波路光TOSスイッチ回路、またはダブルゲートマッハ・ツェンダ型平面導波路光TOSスイッチ回路、またはマッハ・ツェンダ型平面導波路光LNスイッチ回路、またはダブルゲートマッハ・ツェンダ型平面導波路光LNスイッチ回路、または半導体光増幅器(SOA)型2×2光スイッチ回路で構成されることを要旨とする。

【0026】請求項8記載の本発明にあつては、2×2クロス・バー動作光スイッチ回路CS-1は、マッハ・ツェンダ型平面導波路光T〇スイッチ回路、またはダブルゲートマッハ・ツェンダ型平面導波路光T〇スイッチ回路、またはマッハ・ツェンダ型平面導波路光LNスイッチ回路、またはダブルゲートマッハ・ツェンダ型平面導波路光LNスイッチ回路、または半導体光増幅器(S〇A)型2×2光スイッチ回路で構成される。

【0027】また、請求項9記載の本発明は、請求項6または7記載の本発明において、前記2×1透過結合ポート選択光スイッチ回路S-S₁が、マッハ・ツェンダ型平面導波路光TOSスイッチ回路の4つの光入出力ポートのうち、何れか3つの光入出力ポートを用いて実現されたもの、またはダブルゲートマッハ・ツェンダ型平面導波路光TOSスイッチ回路の4つの光入出力ポートのうち、何れか3つの光入出力ポートを用いて実現されたもの、またはダブルゲートマッハ・ツェンダ型平面導波路光TOSスイッチ回路の構成における4つのマッハ・ツェンダ型平面導波路光TOSスイッチ回路部とこれら4つのマッハ・ツェンダ型平面導波路光TOSスイッチ回路部の光入出力ポート間を結ぶ光導波路のうち、何れか3つのマッハ・ツェンダ型平面導波路光TOSスイッチ回路部とこれら3つのマッハ・ツェンダ型平面導波路光TOSスイッチ回路部の光入出力ポート間を結ぶ光導波路のみから構成される2×1透過結合ポート選択光スイッチ回路、またはマッハ・ツェンダ型平面導波路光LSNスイッチ回路の4つの光入出力ポートのうち、何れか3つの光入出力ポートを用いて実現されたもの、またはダブルゲートマッハ・ツェンダ型平面導波路光LSNスイッチ回路の4つの光入出力ポートのうち、何れか3つの光入出力ポートを用いて実現されたもの、またはダブルゲートマッハ・ツェンダ型平面導波路光LSNスイッチ回路の構成における4つのマッハ・ツェンダ型平面導波路光LSNスイッチ回路部とこれら4つのマッハ・ツェンダ型平面導波路光LSNスイッチ回路部の光入出力ポート間を結ぶ光導波路のうち、何れか3つのマッハ・ツェンダ型平面導波路光LSNスイッチ回路部とこれら3つのマッハ・ツェンダ型平面導波路光LSNスイッチ回路部の光入出力ポート間を結ぶ光導波路のみから構成される2×1透過結合ポ

ト選択光スイッチ回路で構成されることを要旨とする。

【0028】請求項9記載の本発明にあっては、 2×1 透過結合ポート選択光スイッチ回路SS-1は、マッハ・ツェンダ型平面導波路光TOスイッチ回路の4つの光入出力ポートのうち、何れか3つの光入出力ポートを用いて実現されたもの、またはダブルゲートマッハ・ツェンダ型平面導波路光TOスイッチ回路の4つの光入出力ポートのうち、何れか3つの光入出力ポートを用いて実現されたもの、またはダブルゲートマッハ・ツェンダ型平面導波路光TOスイッチ回路の構成における4つのマッハ・ツェンダ型平面導波路光TOスイッチ回路部とこれら4つのマッハ・ツェンダ型平面導波路光TOスイッチ回路部の光入出力ポート間を結ぶ光導波路のうち、何れか3つのマッハ・ツェンダ型平面導波路光TOスイッチ回路部とこれら3つのマッハ・ツェンダ型平面導波路光TOスイッチ回路部の光入出力ポート間を結ぶ光導波路のみから構成される 2×1 透過結合ポート選択光スイッチ回路、またはマッハ・ツェンダ型平面導波路光LNスイッチ回路の4つの光入出力ポートのうち、何れか3つの光入出力ポートを用いて実現されたもの、またはダブルゲートマッハ・ツェンダ型平面導波路光LNスイッチ回路の4つの光入出力ポートのうち、何れか3つの光入出力ポートを用いて実現されたもの、またはダブルゲートマッハ・ツェンダ型平面導波路光LNスイッチ回路の構成における4つのマッハ・ツェンダ型平面導波路光LNスイッチ回路部とこれら4つのマッハ・ツェンダ型平面導波路光LNスイッチ回路部の光入出力ポート間を結ぶ光導波路のうち、何れか3つのマッハ・ツェンダ型平面導波路光LNスイッチ回路部とこれら3つのマッハ・ツェンダ型平面導波路光LNスイッチ回路部の光入出力ポート間を結ぶ光導波路のみから構成される 2×1 透過結合ポート選択光スイッチ回路で構成される。

【0029】更に、請求項10記載の本発明は、請求項6記載の本発明において、前記光クロスコネク用スイッチ回路S1-jが、1つのPLC基板平面上に全ての構成光回路が作成されており、基板上面から見て、時計回りに光クロスコネク用スイッチ回路S1-jの第2の光出力ポート、第1の光出力ポート、第3の光出力ポート、第4の光出力ポート、第4の光入力ポート、第3の光入力ポート、第2の光入力ポート、第1の光入力ポートの順に隣り合うように配置され、 2×2 クロス・バー動作光スイッチ回路CS-k ($k=1$)の光入出力ポートが基板上面から見て、時計回りに第2の光入力ポート、第1の光入力ポート、第1の光出力ポート、第2の光出力ポートの順に隣り合うように配置され、4つの 2×1 透過結合ポート選択光スイッチ回路SS-i ($i=1, 2, 3, 4$)の光入出力ポートが基板上面から見て、時計回りに第1の分波側光入出力ポート、第2の分波側光入出力ポート、第1の合波側光入出力ポートの順に隣り合うように配置され、更に、

に、各々の 2×2 クロス・バー動作光スイッチ回路および 2×1 透過結合ポート選択光スイッチ回路の間隔が適度にあたえられることにより、各々の 2×2 クロス・バー動作光スイッチ回路および 2×1 透過結合ポート選択光スイッチ回路の光入力ポート、光出力ポート間を結ぶ何れかの光導波路も交差しない配置になっていることを要旨とする。

【0030】請求項10記載の本発明にあっては、光クロスコネク用スイッチ回路S1-jは1つのPLC基板平面上に全ての構成光回路が作成されており、基板上面から見て、時計回りに光クロスコネク用スイッチ回路S1-jの第2の光出力ポート、第1の光出力ポート、第3の光出力ポート、第4の光出力ポート、第4の光入力ポート、第3の光入力ポート、第2の光入力ポート、第1の光入力ポートの順に各光入力・出力ポートが隣り合うように配置され、 2×2 クロス・バー動作光スイッチ回路CS-k ($k=1$)の光入出力ポートが基板上面から見て、時計回りに第2の光入力ポート、第1の光入力ポート、第1の光出力ポート、第2の光出力ポートの順に隣り合うように配置され、4つの 2×1 透過結合ポート選択光スイッチ回路SS-i ($i=1, 2, 3, 4$)の光入出力ポートが基板上面から見て、時計回りに第1の分波側光入出力ポート、第2の分波側光入出力ポート、第1の合波側光入出力ポートの順に隣り合うように配置され、更に、各々の 2×2 クロス・バー動作光スイッチ回路および 2×1 透過結合ポート選択光スイッチ回路の間隔が適度にあたえられることにより、各々の 2×2 クロス・バー動作光スイッチ回路および 2×1 透過結合ポート選択光スイッチ回路の光入力ポート、光出力ポート間を結ぶ何れかの光導波路も交差しない配置になっている。

【0031】請求項11記載の本発明は、請求項7記載の本発明において、クロスコネク用スイッチSP-jが、1つのPLC基板平面上に全ての構成光回路が作成されており、基板上面から見て、時計回りに光クロスコネク用スイッチSP-jの第2の光出力ポート、第1の光出力ポート、第3の光出力ポート、第4の光出力ポート、第4の光入力ポート、第3の光入力ポート、第2の光入力ポート、第1の光入力ポートの順に各光入力・出力ポートが隣り合うように配置され、4つの 2×2 クロス・バー動作光スイッチ回路CS-k ($k=1, 2, 3, 4$)の光入出力ポートが基板上面から見て、時計回りに第2の光入力ポート、第1の光入力ポート、第1の光出力ポート、第2の光出力ポートの順に隣り合うように配置され、4つの 2×1 透過結合ポート選択光スイッチ回路SS-i ($i=1, 2, 3, 4$)の光入出力ポートが基板上面から見て、時計回りに第1の分波側光入出力ポート、第2の分波側光入出力ポート、第1の合波側光入出力ポートの順に隣り合うように配置され、更に、各々の 2×2 クロス・バー動作光スイッチ回路の間隔が

速度にあたえられることにより、各々の2×2クロス・バー動作光スイッチ回路の光入力ポート、光出力ポート間を結ぶ何れかの光導波路において、2×2クロス・バー動作光スイッチ回路CS-1の第2の光出力ポートと2×1透過結合ポート選択光スイッチ回路SS-2の第2の分波側光入力出力ポートとの間、2×2クロス・バー動作光スイッチ回路CS-2の第1の光出力ポートと2×1透過結合ポート選択光スイッチ回路SS-1の第1の分波側光入力出力ポートとの間をそれぞれ結ぶ光導波路と、2×2クロス・バー動作光スイッチ回路CS-3の第2の光入力ポートと2×1透過結合ポート選択光スイッチ回路SS-4の第1の分波側光入力出力ポートとの間および2×2クロス・バー動作光スイッチ回路CS-4の第1の光入力ポートと2×1透過結合ポート選択光スイッチ回路SS-3の第2の分波側光入力出力ポートとの間をそれぞれ結ぶ光導波路との2組がそれぞれ一箇所ずつ、計2ヶ所のみが交差し、それ以外の光入力ポート、光出力ポート間を結ぶ光導波路の交差がない配置となっていることを要旨とする。

【0032】請求項11記載の本発明においては、クロスコネク用スイッチSP-jは1つのPLC基板平面上に全ての構成光回路が作成されており、基板上面から見て、時計回りに光クロスコネク用スイッチSP-jの第2の光出力ポート、第1の光出力ポート、第3の光出力ポート、第4の光出力ポート、第4の光入力ポート、第3の光入力ポート、第1の光入力ポート、第2の光入力ポートの順に各光入力・出力ポートが隣り合うように配置され、4つの2×2クロス・バー動作光スイッチ回路CS-k (k=1, 2, 3, 4)の光入力出力ポートが基板上面から見て、時計回りに第2の光入力ポート、第1の光入力ポート、第1の光出力ポート、第2の光出力ポートの順に隣り合うように配置され、4つの2×1透過結合ポート選択光スイッチ回路SS-i (i=1, 2, 3, 4)の光入力出力ポートが基板上面から見て、時計回りに第1の分波側光入力出力ポート、第2の分波側光入力出力ポート、第1の合波側光入力出力ポートの順に隣り合うように配置され、更に、各々の2×2クロス・バー動作光スイッチ回路の間隔が適度にあたえられることにより、各々の2×2クロス・バー動作光スイッチ回路の光入力ポート、光出力ポート間を結ぶ何れかの光導波路において、2×2クロス・バー動作光スイッチ回路CS-1の第2の光出力ポートと2×1透過結合ポート選択光スイッチ回路SS-2の第2の分波側光入力出力ポートとの間、2×2クロス・バー動作光スイッチ回路CS-2の第1の光出力ポートと2×1透過結合ポート選択光スイッチ回路SS-1の第1の分波側光入力出力ポートとの間をそれぞれ結ぶ光導波路と、2×2クロス・バー動作光スイッチ回路CS-3の第2の光入力ポートと2×1透過結合ポート選択光スイッチ回路SS-4の第1の分波側光入力出力ポートとの間および2×2クロス

バー動作光スイッチ回路CS-4の第1の光入力ポートと2×1透過結合ポート選択光スイッチ回路SS-3の第2の分波側光入力出力ポートとの間をそれぞれ結ぶ光導波路との2組がそれぞれ一箇所ずつ、計2ヶ所のみが交差し、それ以外の光入力ポート、光出力ポート間を結ぶ光導波路の交差がない配置となっている。

【0033】また、請求項12記載の本発明は、請求項5記載の本発明において、前記光波長合成分波回路が、アレー導波路型光波長合成分波器 (AWG: arrayed-waveguide grating) であることを要旨とする。

【0034】請求項12記載の本発明においては、光波長合成分波回路はアレー導波路型光波長合成分波器である。

【0035】更に、請求項13記載の本発明は、請求項5記載の本発明において、波長合成分波に関する集合A-1, A-2, A-3, A-4を形成し、かつ互いに交差ししない光入出力用導波路を全て持つ1つのアレー導波路平面光回路WM-1と、波長合成分波に関する集合A-5, A-6, A-7, A-8を形成し、かつ互いに交差ししない光入出力用導波路を全て持つ1つのアレー導波路平面光回路WM-2と、各波長チャンネルにそれぞれ対応して個別に配置され、かつ波長チャンネル毎にそれらのいずれかが配置される4入力4出力光クロスコネク用スイッチ回路S1-j, SP-j, および光回路S3-jと、前記アレー導波路平面光回路WM-1, WM-2の光入出力ポートおよび4入力4出力光クロスコネク用スイッチ回路S1-j, SP-j, および光回路S3-j (j=1, 2, ..., N)の光入力ポートおよび光出力ポートのそれぞれに対応するポート同士を結ぶ光導波路とで構成される光波長合成分波回路および光クロスコネク用スイッチ回路部で、前記アレー導波路平面光回路WM-1の各々の集合の分波側の光入出力導波路で任意の波長チャンネルλ_iに対応する光入出力ポートが時計回りまたは反時計回りの何れかの回りで第2, 第1, 第3, 第4の分波側光入出力ポート (A-1/O-d-2-i, A-1/O-d-1-i, A-1/O-d-3-i, A-1/O-d-4-i)の順番で並んでおり、かつこれらの順番に並んでいる光入出力ポートの間には、その他のすべての合波側の光入出力ポートおよび対応する波長チャンネルが異なる分波側の光入出力ポートが入り込まずに、対応する波長チャンネル毎に光入出力ポートがそれぞれ位置的に集団を成しており、前記アレー導波路平面光回路WM-2の各々の集合の分波側の光入出力導波路で任意の波長チャンネルλ_iに対応する光入出力ポートが前記アレー導波路平面光回路WM-1において光入出力ポートが第2, 第1, 第3, 第4の分波側光入出力ポート (A-1/O-d-2-i, A-1/O-d-1-i, A-1/O-d-3-i, A-1/O-d-4-i)の順番となる回りととは逆回りに第6, 第5, 第7, 第8の分波側光入出力ポート (A-1/O-

d-6-i, A-1/O-d-5-i, A-1/O-d-7-i, A-1/O-d-8-i)の順番で並んでおり、かつこれらの順番に並んでいる光入出力ポートの間には、その他のすべての合波側の光入出力ポートおよび対応する波長チャンネルが異なる分波側の光入出力ポートが入り込まずに、対応する波長チャンネル毎に光入出力ポートがそれぞれ位置的に集団を成しており、更に分波側の波長チャンネル毎の光入出力ポートの集団同士の前記アレー導波路平面光回路WM-1の分波側の波長チャンネル毎の光入出力ポートの集団同士の対応する波長チャンネルに閉しての並びの順番とが互いに逆回りて同じ順番となっており、更に、各々の4入力4出力光クロスコネク用スイッチ回路S1-j, SP-j, および光回路S3-j (j=1, 2, ..., N)の光出力ポートの集団同士の対応する波長チャンネルに閉しての並びの順番と前記アレー導波路平面光回路WM-1の分波側の波長チャンネル毎の光入出力ポートの集団同士の対応する波長チャンネルに閉しての並びの順番とが互いに逆回りて同じ順番となっており、かつ各々の4入力4出力光クロスコネク用スイッチ回路S1-j, SP-j, および光回路S3-j (j=1, 2, ..., N)の光出力ポートの集団同士の対応する波長チャンネルに閉しての並びの順番と前記アレー導波路平面光回路WM-1の分波側の波長チャンネル毎の光入出力ポートの集団同士の対応する波長チャンネルに閉しての並びの順番とが互いに逆回りて同じ順番となっていることにより、同一平面上でアレー導波路平面光回路WM-1, WM-2と4入力4出力光クロスコネク用スイッチ回路S1-j, SP-j, および光回路S3-j (j=1, 2, ..., N)とを結ぶ光導波路同士で互いに交差するものが1つもないような回路の配置および構成であり、アレー導波路平面光回路WM-1, WM-2および4入力4出力光クロスコネク用スイッチ回路S1-j, SP-j, および光回路S3-j (j=1, 2, ..., N)と、アレー導波路平面光回路WM-1, WM-2および4入力4出力光クロスコネク用スイッチ回路S1-j, SP-j, および光回路S3-j (j=1, 2, ..., N)間をそれぞれ結ぶ光導波路とを同一平面基板上に作成するか、または個別の作成された光波長台分波部の平面回路基板と光クロスコネク用スイッチ回路の平面回路基板とを突き合わせする形で各々の光入出力ポート同士を結合し、1つの平面状光回路を形成することを要旨とする。

【0036】請求項13記載の本発明にあっては、波長台分波に関する集合A-1, A-2, A-3, A-4を形成し、かつ互いに交差しない光入出力用導波路を全て持つ1つのアレー導波路平面光回路WM-1と、波長台分波に関する集合A-5, A-6, A-7, A-8を形成し、かつ互いに交差しない光入出力用導波路を全て持つ1つのアレー導波路平面光回路WM-2と、各波長チ

ャンネルにそれぞれ対応して個別に配置され、かつ波長チャンネル毎にそれらのいずれかが配置される4入力4出力光クロスコネク用スイッチ回路S1-j, SP-j, および光回路S3-jと、前記アレー導波路平面光回路WM-1, WM-2の光入出力ポートおよび4入力4出力光クロスコネク用スイッチ回路S1-j, SP-j, および光回路S3-j (j=1, 2, ..., N)の光入出力ポートおよび光出力ポートのそれぞれに対応するポート同士を結ぶ光導波路とで構成される光波長台分波回路および光クロスコネク用スイッチ回路部で、前記アレー導波路平面光回路WM-1の各々の集合の分波側の光入出力導波路で任意の波長チャンネル入1に対応する光入出力ポートが時計回りまたは反時計回りの何れかの回りで第2, 第1, 第3, 第4の分波側光入出力ポート(A-1/O-d-2-i, A-1/O-d-1-i, A-1/O-d-3-i, A-1/O-d-4-i)の順番で並んでおり、かつこれらの順番に並んでいる光入出力ポートの間には、その他のすべての合波側の光入出力ポートおよび対応する波長チャンネルが異なる分波側の光入出力ポートが入り込まずに、対応する波長チャンネル毎に光入出力ポートがそれぞれ位置的に集団を成しており、前記アレー導波路平面光回路WM-2の各々の集合の分波側の光入出力導波路で任意の波長チャンネル入1に対応する光入出力ポートが前記アレー導波路平面光回路WM-1において光入出力ポートが第2, 第1, 第3, 第4の分波側光入出力ポート(A-1/O-d-2-i, A-1/O-d-1-i, A-1/O-d-3-i, A-1/O-d-4-i)の順番となる回りと逆回りに第6, 第5, 第7, 第8の分波側光入出力ポート(A-1/O-d-6-i, A-1/O-d-5-i, A-1/O-d-7-i, A-1/O-d-8-i)の順番で並んでおり、かつこれらの順番に並んでいる光入出力ポートの間には、その他のすべての合波側の光入出力ポートおよび対応する波長チャンネルが異なる分波側の光入出力ポートが入り込まずに、対応する波長チャンネル毎に光入出力ポートがそれぞれ位置的に集団を成しており、更に分波側の波長チャンネル毎の光入出力ポートの集団同士の対応する波長チャンネルに閉しての並びの順番と前記アレー導波路平面光回路WM-1の分波側の波長チャンネル毎の光入出力ポートの集団同士の対応する波長チャンネルに閉しての並びの順番とが互いに逆回りて同じ順番となっており、更に、各々の4入力4出力光クロスコネク用スイッチ回路S1-j, SP-j, および光回路S3-j (j=1, 2, ..., N)の光出力ポートの集団同士の対応する波長チャンネルに閉しての並びの順番と前記アレー導波路平面光回路WM-1の分波側の波長チャンネル毎の光入出力ポートの集団同士の対応する波長チャンネルに閉しての並びの順番とが互いに逆回りて同じ順番となっており、かつ各々の4入力4出力光クロスコネク用スイッチ回路S

1-j, SP-j, および光回路S3-j (j=1, 2, ..., N) の光出力ポートの集団としての対応する波長チャンネルに於ける並びの順序と前記アレー導波路平面光回路WM-1の分波側の波長チャンネル毎の光入出力ポートの集団としての対応する波長チャンネルに於ける並びの順序とが互いに逆回りで同じ順序となっていることにより、同一平面上でアレー導波路平面光回路WM-1, WM-2と4入力4出力光クロスコネク用スイッチ回路S1-j, SP-j, および光回路S3-j (j=1, 2, ..., N) とを結合光導波路同士で互いに交差するものが1つもないような回路の配置および構成であり、アレー導波路平面光回路WM-1, WM-2および4入力4出力光クロスコネク用スイッチ回路S1-j, SP-j, および光回路S3-j (j=1, 2, ..., N) と、アレー導波路平面光回路WM-1, WM-2および4入力4出力光クロスコネク用スイッチ回路S1-j, SP-j, および光回路S3-j (j=1, 2, ..., N) 間をそれぞれ結合光導波路とを同一平面基板に作成するか、または個別の作成された光波長分波部の平面回路基板と光クロスコネク用スイッチ回路の平面回路基板とを突き合わせする形で各々の光入出力ポート同士を結合し、1つの平面状光回路を形成する。

【0037】請求項14記載の本発明は、請求項9記載の本発明において、前記光サークキュレータにおいて、光入力ポートに入力された光が、光入出力ポートから出力され、光入出力ポートから入力された光は、光出力ポートから出力され、光入出力ポートから入力され光入出力ポートから出力される光は、十分に抑圧され、光出力ポート

入出力ポートの集合Bの和集合C($\cup A \cup B$)が波長チャンネルの集合しに於て

る波長分波に於ける集合を形成すると表現し、前記入出力ポートaを波長側の入出力ポートと表現し、前記入出力ポートの集合Bの要素である入出力ポートを分波側の入出力ポートと表現する。

【0042】【定義2】互いに素である2つの入出力ポート(導波路)の集合A, B ($A \cap B = \emptyset$)があり、入出力ポート(導波路)の集合Aの要素である入出力ポート(導波路)と入出力ポート(導波路)の集合Bの要素である入出力ポート(導波路)との各々総ての入出力ポート(導波路)間に問題とする波長領域内の透過波長チャンネルが少なくとも1つずつ存在し、各々の集合内の入出力ポート(導波路)間では透過波長チャンネルが存在しない場合(すなわち、入出力ポート(導波路)の集合Aの要素のある入出力ポート(導波路)aから信号光Lが入力された場合、入出力ポート(導波路)の集合Bの要素の何れか対応する入出力ポート(導波路)bから信号光Lが出力され、逆に入出力ポート(導波路)の集合Bの要素の入出力ポート(導波路)bから信号光Lが入力された場合、入出力ポート(導波路)の集合Aの要素の入出力ポート(導波路)aから信号光Lが出力され、入出力ポートの集合Aの要素間、および入出力ポ

*トから入力され、光入出力ポートから出力される光は、十分に抑圧され、光入力ポートと光出力ポートとの間では光の入出力の向きに関わらず光が十分に抑圧されることを要旨とする。

【0038】請求項14記載の本発明に於ては、光サークキュレータにおいて、光入力ポートに入力された光は、光入出力ポートから出力され、光入出力ポートから入力された光は、光出力ポートから出力され、光入出力ポートから入力され光入出力ポートから出力される光は、十分に抑圧され、光出力ポートから入力され、光入出力ポートから出力される光は、十分に抑圧され、光入力ポートと光出力ポートとの間では光の入出力の向きに関わらず光が十分に抑圧される。

【0039】

【発明の実施の形態】以下、図面を用いて本発明の実施の形態を説明する。

【0040】まず最初に、本実施形態で用いる表現の定義を以下に記載する。

【0041】【定義1】ある入出力ポートaと該入出力ポートaを要素に含まない入出力ポートの集合Bとがあり、入出力ポートの集合Bを定義域として前記入出力ポートaとの間の透過波長チャンネルを対応させる上への1:1の写像(onto one-to-one mapping)の値域である波長チャンネルの集合しが存在する場合、入出力ポートaを唯一の要素とする入出力ポートの集合A ($A = \{a\}$)と

【外1】

30 トの集合Bの要素間では、信号光が入出力されない)、入出力ポート(導波路)の集合A, Bは、互いに排他的に入出力ポート(導波路)、出力ポート(導波路)となると表現する。

【0043】次に、本発明の光バス・アレイ用光回路において使用される光波長分波回路として、望ましいAWGの構成および本発明の光回路の構成上の重要な光部品であるAWGと該AWGが本発明に係る光回路を構成する光波長分波回路に要求されると特性、すなわち1つのAWGの有する光入出力ポートがある波長チャンネルの集合に対する波長分波に関する入出力ポートの集合で互いに素である複数の集合を形成し得るという特性を満足することの証明を示す。

【0044】まず、AWGの構成について図1を参照して説明する。図1は、 $N \times N$ AWG ($N=16$)の回路構成を示す図である。

【0045】図1に示す $N \times N$ AWG ($N=16$)は、2つのスラブ導波路部10-1, 10-2と、この2つのスラブ導波路部のそれぞれに接続された光入出力導波路部9-1, 9-2と、前記2つのスラブ導波路部10-1, 10-2の間を連結し、隣接導波路長がある

適当な固定長ずつ増減または増減する光導波路の集まりからなるアレー導波路グレーティング部11とから構成されている。

【0046】また、光入出力導波路部9-1、9-2は、それぞれ互いに相補的に入力導波路および出力導波路になり、それぞれの要素数がN個である入出力導波路の集合から構成されている。

【0047】更に、 $N \times N$ AWG ($N=16$) は、互いに相補的に入力ポートおよび出力ポートとなる入出力ポートの集合である $LP = \{L-P, n\}$ ($n=1, 2, \dots, 16$) および $RP = \{R-P, m\}$ ($m=1, 2, \dots, 16$) を有している。

【0048】但し、フリースペクトラル (FSR)、波長チャンネル間隔 ($\Delta\lambda$) および片側の入出力ポート数 N との間で $N = FSR / \Delta\lambda$ なる関係を満足している $N \times N$ AWG の一方のスラブ導波路10-1から延びている光入出力導波路部9-1を構成する光導波路で、2つのスラブ導波路部10-1、10-2を結ぶアレー導波路グレーティング部11の導波路長の最も長い光導波路に隣接して延びている光導波路側から順にそれぞれの光導波路の導く入出力ポートに1、2、…、 N とポート番号を割り当て、一方のスラブ導波路10-1から延びている入出力ポートの集合を他方のスラブ導波路10-2から延びている入出力ポートの集合と識別する記号 $L-*$

* P 、と併せて $L-P, 1, L-P, 2, \dots, L-P, N$ と表し、他方のスラブ導波路10-2から延びており、2つのスラブ導波路部10-1、10-2を結ぶアレー導波路グレーティング部11の導波路長の最も長い光導波路に隣接して延びている光入出力導波路部9-2を構成する光導波路側から順にそれぞれの光導波路の導く入出力ポートに1、2、…、 N とポート番号を割り当て、スラブ導波路10-2から延びている入出力ポートの集合をスラブ導波路10-1から延びている入出力ポートの集合と識別する記号 $R-P$ 、と併せて $R-P, 1, R-P, 2, \dots, R-P, N$ と表すものとする。

【0049】次に、AWGが本発明に係る光増幅器を構成する光波長合分波回路に要求される特性を満足することについての証明を行う。

【0050】上述したように、各入出力ポートを入出力ポートを識別する記号と入出力ポート番号からなる $L-P, 1, L-P, 2, \dots, L-P, N, R-P, 1, R-P, 2, \dots, R-P, N$ で表すとき、 $N \times N$ AWG (中心透過波長チャンネル λ_c 、波長チャンネル間隔 $\Delta\lambda$) の互いに相補的に入力ポート、出力ポートとなる入出力ポート $L-P, n$ (n は N 以下の自然数) と入出力ポート $R-P, m$ (m は N 以下の自然数) との透過波長 $\lambda(n, m)$ は、入出力ポート番号 n, m を用いて、

【数1】

$$\begin{aligned} \lambda(n, m) &= \lambda_c + \Delta\lambda(n+m-N/2), \\ &\quad (0 < n+m-N/2 \leq N) \quad \dots (1) \\ &= \lambda_c + \Delta\lambda(n+m+N/2), \\ &\quad (n+m-N/2 \leq 0) \quad \dots (2) \\ &= \lambda_c + \Delta\lambda(n+m-3N/2), \\ &\quad (N < n+m-N/2) \quad \dots (3) \end{aligned}$$

と表すことができる。

【0051】例えば、上述したように、適宜入出力ポートに番号を割り当てたばあいの $N \times N$ AWG ($N=16$, $FSR=N\Delta\lambda$) の入出力ポート $L-P, 6, L-P, 7, L-P, 8, L-P, 9$ と入出力ポート $\{R-P, m\}$ ($m=1, 2, \dots, 16$) との間の透過波長は表1に示すような関係となる。

【0052】

【表1】

【表1】

	L-P.9	L-P.8	L-P.7	L-P.6
R-P.1	$\lambda.2$	$\lambda.1$	$\lambda.16$	$\lambda.15$
R-P.2	$\lambda.3$	$\lambda.2$	$\lambda.1$	$\lambda.16$
R-P.3	$\lambda.4$	$\lambda.3$	$\lambda.2$	$\lambda.1$
R-P.4	$\lambda.5$	$\lambda.4$	$\lambda.3$	$\lambda.2$
R-P.5	$\lambda.6$	$\lambda.5$	$\lambda.4$	$\lambda.3$
R-P.6	$\lambda.7$	$\lambda.6$	$\lambda.5$	$\lambda.4$
R-P.7	$\lambda.8$	$\lambda.7$	$\lambda.6$	$\lambda.5$
R-P.8	$\lambda.9$	$\lambda.8$	$\lambda.7$	$\lambda.6$
R-P.9	$\lambda.10$	$\lambda.9$	$\lambda.8$	$\lambda.7$
R-P.10	$\lambda.11$	$\lambda.10$	$\lambda.9$	$\lambda.8$
R-P.11	$\lambda.12$	$\lambda.11$	$\lambda.10$	$\lambda.9$
R-P.12	$\lambda.13$	$\lambda.12$	$\lambda.11$	$\lambda.10$
R-P.13	$\lambda.14$	$\lambda.13$	$\lambda.12$	$\lambda.11$
R-P.14	$\lambda.15$	$\lambda.14$	$\lambda.13$	$\lambda.12$
R-P.15	$\lambda.16$	$\lambda.15$	$\lambda.14$	$\lambda.13$
R-P.16	$\lambda.1$	$\lambda.16$	$\lambda.15$	$\lambda.14$

ここで、 $N \times N$ AWGが本発明の光増幅器に必要な光波長分波回路に要求される特性を満足すること、すなわち $0 < j < N$ を満足する任意の整数 j に対して *

$$\begin{aligned} & \lambda(j, 2k+1) - \lambda(j-1, 2k+2) \\ &= \Delta\lambda([2k+1] + j - N/2) - \Delta\lambda([2k+2] + [j-1] - N/2) \\ &= 0 \end{aligned}$$

或いは

※30※【数3】

$$\begin{aligned} & \lambda(j, 2k+1) - \lambda(j-1, 2k+2) \\ &= \Delta\lambda([2k+1] + j + N/2) - \Delta\lambda([2k+2] + [j-1] + N/2) \\ &= 0 \end{aligned}$$

或いは

★ ★【数4】

$$\begin{aligned} & \lambda(j, 2k+1) - \lambda(j-1, 2k+2) \\ &= \Delta\lambda([2k+1] + j - 3N/2) - \Delta\lambda([2k+2] + [j-1] - 3N/2) \\ &= 0 \end{aligned}$$

となり、いずれの場合でも同一波長であることがわかる。

【0056】従って、 $0 < j < N$ を満足する任意の整数 j に対する入出力ポート $L-P. j$ と入出力ポートの集合 $C = \{R-P. 2k' + 1 : k' = 0, 1, 2, \dots, N/2 - 1\}$ の要素である入出力ポートとの間の透過波長の場合 $L' = \{\lambda(j, 2k' + 1) : k' = 0, 1, 2, \dots, N/2 - 1\}$ と、入出力ポート $L-P. j-1$ と入出力ポートの集合 $D = \{R-P. 2k'' + 2 : k'' = 0, 1, 2, \dots, N/2 - 1\}$ の要素である入出力ポートとの間の透過波長の集合 $L'' = \{\lambda(j-1, 2k'' + 2) : k'' = 0, 1, 2, \dots, N/2 - 1\}$ と、入出力ポート $L-P. j$ と入出力ポートの集合 $D = \{R-P. 2k'' + 2 : k'' = 0, 1, 2, \dots, N/2 - 1\}$ とが互いに素であり、かつ、同一の波長チャンネルの集合に対する波長分波に関しての集合となっていることを示す。

【0053】まず、 $0 < j < N$ を満足する任意の整数 j と $0 \leq k \leq N/2 - 1$ を満足する任意の整数 k に対して、入出力ポート $L-P. j$ と入出力ポート $R-P. 2k+1$ とのポート間の透過波長 $\lambda(j, 2k+1)$ と、入出力ポート $L-P. j-1$ と入出力ポート $R-P. 2k+2$ とのポート間の透過波長 $\lambda(j-1, 2k+2)$ との関係は以下で求める。

【0054】上記の二組の入出力ポートの組に於いてお互いに相補的に入力ポート・出力ポートとなるポート間のポート番号の和は、上記の任意の整数 k, j を用いて、
 $n + m = 2k + 1 + j = 2k + 2 + (j - 1)$
と表すことができ、両者の値が常に等しくなる。

【0055】従って、上記の透過波長 $\lambda(j, 2k+1)$ と $\lambda(j-1, 2k+2)$ とは、いずれの場合でも上記の式(1)、(2)、或いは(3)の何れかの同じ式で表されるので透過波長 $\lambda(j, 2k+1)$ と $\lambda(j-1, 2k+2)$ との差は、

$$\lambda(j, 2k+1) - \lambda(j-1, 2k+2)$$

【数2】
 $\lambda(j, 2k+1) - \lambda(j-1, 2k+2)$
 $= \Delta\lambda([2k+1] + j - N/2) - \Delta\lambda([2k+2] + [j-1] - N/2)$
 $= 0$

【数2】

$$\begin{aligned} & \lambda(j, 2k+1) - \lambda(j-1, 2k+2) \\ &= \Delta\lambda([2k+1] + j + N/2) - \Delta\lambda([2k+2] + [j-1] + N/2) \\ &= 0 \end{aligned}$$

※30※【数3】

$$\begin{aligned} & \lambda(j, 2k+1) - \lambda(j-1, 2k+2) \\ &= \Delta\lambda([2k+1] + j - 3N/2) - \Delta\lambda([2k+2] + [j-1] - 3N/2) \\ &= 0 \end{aligned}$$

★ ★【数4】

$$\begin{aligned} & \lambda(j, 2k+1) - \lambda(j-1, 2k+2) \\ &= \Delta\lambda([2k+1] + j - 3N/2) - \Delta\lambda([2k+2] + [j-1] - 3N/2) \\ &= 0 \end{aligned}$$

20 $2k'' + 2 : k'' = 0, 1, 2, \dots, N/2 - 1\}$ と、 $k' = k''$ を満足する要素同士がそれぞれ等しいので、等しい ($L' = L''$)。

【0057】さらに、このとき分波側の入出力ポートの集合 $C = \{R-P. 2k' + 1\} (k' = 0, 1, \dots, N/2 - 1)$ と入出力ポートの集合 $D = \{R-P. 2k'' + 2\} (k'' = 0, 1, \dots, N/2 - 1)$ とのポート番号の差が $(2k' + 1) - (2k'' + 2) = 2(k' - k'') - 1$ と表すことができ、いかなる自然数 k', k'' の組み合わせに対しても決して値が0とならないことから入出力ポートの集合 C と D とが互いに素で

あり、互いに共通の要素（入出力ポート）を持たないことがわかる。

【0058】従って、 $0 < j < N$ を満足する任意の整数 j に対しての入出力ポートの集合 $\{L-P, j, R-P, 2k^*+1 (k^*=0, 1, 2, \dots, N/2-1)\}$ と入出力ポートの集合 $\{L-P, j-1, R-P, 2k^*+2 (k^*=0, 1, 2, \dots, N/2-1)\}$ とは互いに素であり、かつ、同一の波長チャンネルの集合に対する波長合分波に関する集合である。

【0059】また、同様に $0 < j < N$ を満足する任意の整数 j に対しての入出力ポートの集合 $\{L-P, j, R-P, 3k^*+1 (k^*=0, 1, 2, \dots, N/3-1)\}$ と入出力ポートの集合 $\{L-P, j-1, R-$

$$\begin{aligned} & (3k^*+1) - (3k^*+2) = 3(k^*-k^*) - 1 \\ & (3k^*+1) - (3k^*+3) = 3(k^*-k^*) - 2 \\ & (3k^*+2) - (3k^*+3) = 3(k^*-k^*) - 3 \end{aligned}$$

といかなる自然数 k^*, k^*, k^* に対しても決して0とならないことから $0 < j < N$ を満足する任意の整数 j に対しての入出力ポートの集合 $\{L-P, j, R-P, 3k^*+1 (k^*=0, 1, 2, \dots, N/3-1)\}$ と入出力ポートの集合 $\{L-P, j-1, R-P, 3k^*+2 (k^*=0, 1, 2, \dots, N/3-1)\}$ と入出力ポートの集合 $\{L-P, j-2, R-P, 3k^*+3 (k^*=0, 1, 2, \dots, N/3-1)\}$ とは互いに素であり、かつ、同一の波長チャンネルの集合に対する波長合分波に関する集合である。

【0060】さらにまた、同様に $0 < j < N$ を満足する任意の整数 j に対しての入出力ポートの集合 $\{L-P, j, R-P, 4k^*+1 (k^*=0, 1, 2, \dots, N/4-1)\}$ と入出力ポートの集合 $\{L-P, j-1, R-$

$$\begin{aligned} & (4k^*+1) - (4k^*+2) = 4(k^*-k^*) - 1 \\ & (4k^*+1) - (4k^*+3) = 4(k^*-k^*) - 2 \\ & (4k^*+1) - (4k^*+4) = 4(k^*-k^*) - 3 \\ & (4k^*+2) - (4k^*+3) = 4(k^*-k^*) - 1 \\ & (4k^*+2) - (4k^*+4) = 4(k^*-k^*) - 2 \\ & (4k^*+3) - (4k^*+4) = 4(k^*-k^*) - 1 \end{aligned}$$

といかなる自然数 k^*, k^*, k^* に対しても決して0とならないことから $0 < j < N$ を満足する任意の整数 j に対しての入出力ポートの集合 $\{L-P, j, R-P, 4k^*+1 (k^*=0, 1, 2, \dots, N/4-1)\}$ と入出力ポートの集合 $\{L-P, j-1, R-P, 4k^*+2 (k^*=0, 1, 2, \dots, N/4-1)\}$ と入出力ポートの集合 $\{L-P, j-2, R-P, 4k^*+3 (k^*=0, 1, 2, \dots, N/4-1)\}$ と入出力ポートの集合 $\{L-P, j-3, R-P, 4k^*+4 (k^*=0, 1, 2, \dots, N/4-1)\}$ とは互いに素であり、かつ、同一の波長チャンネルの集合に対する波長合分波に関する集合である。

* $P, 3k^*+2 (k^*=0, 1, 2, \dots, N/3-1)\}$ と入出力ポートの集合 $\{L-P, j-2, R-P, 3k^*+3 (k^*=0, 1, 2, \dots, N/3-1)\}$ とに関して、 $0 \leq k < N/2$ を満足する任意の整数 k に対して、お互いに相補的に入力ポート・出力ポートとなるポート間のポート番号の和が上記の任意の整数 k, j を用いて $n+m=j+(3k+1)=(j-1)+(3k+2)=(j-2)+(3k+3)$ と表すことができ、三者の値が常に等しいこと、および上記にあるそれぞれの入出力ポートの集合間の合波側ポートのポート番号の差、

【数5】

* $-P, 4k^*+2 (k^*=0, 1, 2, \dots, N/4-1)\}$ と入出力ポートの集合 $\{L-P, j-2, R-P, 4k^*+3 (k^*=0, 1, 2, \dots, N/4-1)\}$ と入出力ポートの集合 $\{L-P, j-3, R-P, 4k^*+4 (k^*=0, 1, 2, \dots, N/4-1)\}$ とに関して $0 \leq k < N/2$ を満足する任意の整数 k に対して、お互いに相補的に入力ポート・出力ポートとなるポート間のポート番号の和が上記の任意の整数 k, j を用いて $n+m=j+(4k+1)=(j-1)+(4k+2)=(j-2)+(4k+3)=(j-3)+(4k+4)$ と表すことができ、四者が常に等しいこと、および上記にあるそれぞれの入出力ポートの集合間の合波側ポートのポート番号の差、

【数6】

【0061】以下、形成する入出力ポートの集合の数 N' と N とが $N/N'-1 \geq 0$ を満足する限りにおいて同様のことが言える。

【0062】以上から $N \times N$ AWGは、互いに素であり、かつ、同一波長チャンネルの集合に対する波長合分波に関して集合を形成する複数の入出力ポートの集合を持ち本発明の光増幅器に必要となる光波長合分波回路に要求される特性を満足することがわかる。

【0063】以上のようにして、AWGが本発明に係る光増幅器を構成する光波長合分波回路に要求される特性を満足することが証明される。

【0064】次に、図2に示す光クロスコネクタ用スイッチ回路 $S1-j$ が満たすべき動作を全て満足するスイ

ッチ構成であることを示すとともに、また図3に示す光クロスコネク用スイッチSP-jが満たすべき動作を全て満足するスイッチ構成であることを示す。

【0065】図2に示す光クロスコネク用スイッチ回路S1-jは、1つの2入力2出力クロス・バー動作光スイッチ回路CS-i (i=1)、および4つの2×1透過結合ポート選択光スイッチ回路SS-i (i=1, 2, 3, 4) から構成されている。

【0066】また、図3に示す光クロスコネク用スイッチSP-jは、4つの2入力2出力クロス・バー動作光スイッチ回路CS-i (i=1, 2, 3, 4)、および4つの2×1透過結合ポート選択光スイッチ回路SS-i (i=1, 2, 3, 4) から構成されている。

【0067】ここで、構成要素である2入力2出力クロス・バー動作光スイッチ回路CS-iの2つの光入出力ポートCS-i-1-1、CS-i-1-2と2の光入出力ポートCS-i-1-O-1、CS-i-1-O-2間の透過・遮断スイッチ動作は、一般的にクロス・バースイ

【表2(a)】

スイッチ動作	入出力ポート間の透過/遮断状態	スイッチ動作表記
バー	CS-i-1-1<->CS-i-1-O-1 AND CS-i-1-2<->CS-i-1-O-2 AND CS-i-1-1<->CS-i-1-O-2 AND CS-i-1-2<->CS-i-1-O-1	0
クロス	CS-i-1-1<->CS-i-1-O-2 AND CS-i-1-2<->CS-i-1-O-1 AND CS-i-1-1<->CS-i-1-O-1 AND CS-i-1-2<->CS-i-1-O-2	1

<->透過、<-/->遮断

【表3】

【表2(b)】

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スイッチ動作	入出力ポート間の透過/遮断状態	スイッチ動作表記
-	SS-i-1/O-L-1<->SS-i-1/O-R-1 AND SS-i-1/O-L-2<->SS-i-1/O-R-2	0
-	SS-i-1/O-L-1<->SS-i-1/O-R-2 AND SS-i-1/O-L-2<->SS-i-1/O-R-1	1

<->透過、<-/->遮断

このようなクロス・バー型の透過・遮断スイッチ動作を実現する光スイッチ回路としては、マッハ・ツェンダ型平面導波路光TOスイッチ回路(IEICE, Trans. Electro n., E76-C, p.1215, 1993 参照)、ダブルゲートマッハ・ツェンダ型平面導波路光TOスイッチ回路(Electron Letter 32., p.1471, 1996 参照)、マッハ・ツェンダ型平面導波路光LNスイッチ回路、ダブルゲートマッハ・ツェンダ型平面導波路光LNスイッチ回路、半導体光増幅器(SOA)型2×2光スイッチ回路(小松啓郎, OPTRONIC

S No. 12, pp.139-144, 1997 参照)などがある。

【0069】2×1透過結合ポート選択光スイッチ回路SS-iの動作は、上記クロス・バー型透過・遮断スイッチ動作を実現する光スイッチ回路の任意の1つの入出力ポートを使用しないか、スイッチ動作に影響を与えない範囲で回路を簡素化することにより実現される。

【0070】上述した2入力2出力クロス・バー動作光スイッチ回路CS-1と2×1透過結合ポート選択光スイッチ回路SS-i (i=1, 2, 3, 4) によって図

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【表4】

【表3(a)】

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1の光入力ポートと第4の光出力ポートとの間および第3の光入力ポートと第2の光出力ポートとの間を除く全ての光入力ポートと光出力ポートとの間で信号光を遮断するか、または第1の光入力ポートと第3の光出力ポートとの間および第4の光入力ポートと第2の光出力ポートとの間で信号光を透過させ、かつ第1の光入力ポートと第3の光出力ポートとの間および第4の光入力ポートと第2の光出力ポートとの間を除く全ての光入力ポートと光出力ポートとの間で信号光を遮断するか、または第2の光入力ポートと第1の光出力ポートとの間および第3の光入力ポートと第4の光出力ポートとの間で信号光を透過させ、かつ第2の光入力ポートと第1の光出力ポートとの間および第3の光入力ポートと第4の光出力ポートとの間を除く全ての光入力ポートと光出力ポートとの間で信号光を遮断するか、または第2の光入力ポートと第1の光出力ポートとの間および第4の光入力ポート

と第3の光出力ポートとの間で信号光を透過させ、かつ第2の光入力ポートと第1の光出力ポートとの間および第4の光入力ポートと第3の光出力ポートとの間を除く全ての光入力ポートと光出力ポートとの間で信号光を遮断するか、または第2の光入力ポートと第3の光出力ポートとの間および第4の光入力ポートと第1の光出力ポートとの間で信号光を透過させ、かつ第2の光入力ポートと第3の光出力ポートとの間および第4の光入力ポートと第1の光出力ポートとの間を除く全ての光入力ポートと光出力ポートとの間で信号光を遮断するか、または第2の光入力ポートと第4の光出力ポートとの間および第3の光入力ポートと第1の光出力ポートとの間で信号光を透過させ、かつ第2の光入力ポートと第4の光出力ポートとの間および第3の光入力ポートと第1の光出力ポートとの間を除く全ての光入力ポートと光出力ポート

との間で信号光を遮断するかを光クロスコネク用スイッチ回路S1-jは任意に選択することができる。

【0073】また、2入力2出力クロス・バー動作光スイッチ回路CS-i (i=1, 2, 3, 4)と2×1透過結合ポート選択光スイッチ回路SS-i (i=1, 2, 3, 4)によって図3に示すような光クロスコネク用スイッチSP-jを構成し、各構成要素である光スイッチ回路の動作状態を表3(b)に示すような組合せとなのように同調させながら動作させることにより光クロスコネク用スイッチSP-jにより光入力ポート、光出力ポート間の透過、遮断スイッチ動作を実現させることができる。

【0074】

【表5】

【表3(b)】

No.	各要素のスイッチ動作状態 (CS-1, CS-2, CS-3, CS-4, SS-1, SS-2, SS-3, SS-4)	光クロスコネクタ用スイッチ回路 のスイッチ動作状態
1	(1, 1, 0, 0) (1, 0, 0, 1) (0, 0, 1, 1) (0, 1, 1, 0)	3-ポート1, 3-ポート2間, 3-ポート3, 3-ポート4間が透過 且つ 3-ポート1, 3-ポート2間, 3-ポート3, 3-ポート4間 を除く全ての入出力ポート間が遮断
2	(1, 0, 0, 1) (1, 0, 0, 1) (0, 1, 1, 0) (0, 1, 1, 0)	3-ポート1, 3-ポート2間, 3-ポート4, 3-ポート3間が透過 且つ 3-ポート1, 3-ポート2間, 3-ポート4, 3-ポート3間 を除く全ての入出力ポート間が遮断
3	(1, 1, 1, 1) (1, 0, 1, 0) (0, 0, 0, 0) (0, 1, 0, 1)	3-ポート1, 3-ポート4間, 3-ポート3, 3-ポート2間が透過 且つ 3-ポート1, 3-ポート4間, 3-ポート3, 3-ポート2間 を除く全ての入出力ポート間が遮断
4	(1, 0, 1, 0) (1, 0, 1, 0) (0, 1, 0, 1) (0, 1, 0, 1)	3-ポート1, 3-ポート3間, 3-ポート4, 3-ポート2間が透過 且つ 3-ポート1, 3-ポート3間, 3-ポート4, 3-ポート2間 を除く全ての入出力ポート間が遮断
5	(0, 1, 1, 0) (1, 0, 0, 1) (1, 0, 0, 1) (0, 1, 1, 0)	3-ポート2, 3-ポート1間, 3-ポート3, 3-ポート4間が透過 且つ 3-ポート2, 3-ポート1間, 3-ポート3, 3-ポート4間 を除く全ての入出力ポート間が遮断
6	(0, 0, 1, 1) (1, 0, 0, 1) (1, 1, 0, 0) (0, 1, 1, 0)	3-ポート2, 3-ポート1間, 3-ポート4, 3-ポート3間が透過 且つ 3-ポート2, 3-ポート1間, 3-ポート4, 3-ポート3間 を除く全ての入出力ポート間が遮断
7	(0, 1, 0, 1) (1, 0, 1, 0) (1, 0, 1, 0) (0, 1, 0, 1)	3-ポート2, 3-ポート4間, 3-ポート3, 3-ポート1間が透過 且つ 3-ポート2, 3-ポート4間, 3-ポート3, 3-ポート1間 を除く全ての入出力ポート間が遮断
8	(0, 0, 0, 0) (1, 0, 1, 0) (1, 1, 1, 1) (0, 1, 0, 1)	3-ポート2, 3-ポート3間, 3-ポート4, 3-ポート1間が透過 且つ 3-ポート2, 3-ポート3間, 3-ポート4, 3-ポート1間 を除く全ての入出力ポート間が遮断
9	(1, N, N, 0) (1, 1, 1, 1) (0, N, N, 1) (1, 1, 1, 1)	3-ポート1, 3-ポート2間, 3-ポート2, 3-ポート4間が透過 且つ 3-ポート1, 3-ポート2間, 3-ポート2, 3-ポート4間 を除く全ての入出力ポート間が遮断
10	(1, N, N, 1) (1, 1, 1, 1) (0, N, N, 0) (1, 1, 1, 1)	3-ポート1, 3-ポート4間, 3-ポート2, 3-ポート3間が透過 且つ 3-ポート1, 3-ポート4間, 3-ポート2, 3-ポート3間 を除く全ての入出力ポート間が遮断
11	(N, 1, 0, N) (0, 0, 0, 0) (N, 0, 1, N) (0, 0, 0, 0)	3-ポート3, 3-ポート1間, 3-ポート4, 3-ポート2間が透過 且つ 3-ポート3, 3-ポート1間, 3-ポート4, 3-ポート2間 を除く全ての入出力ポート間が遮断
12	(N, 1, 1, N) (0, 0, 0, 0) (N, 0, 0, N) (0, 0, 0, 0)	3-ポート3, 3-ポート2間, 3-ポート4, 3-ポート1間が透過 且つ 3-ポート3, 3-ポート2間, 3-ポート4, 3-ポート1間 を除く全ての入出力ポート間が遮断

注. 表記“N”は、0でも1でもどちらでも可

すなわち、光クロスコネクタ用スイッチSP-1は、次のような動作を実現することができる。

【0075】第1の光入力ポートと第2の光出力ポートとの間および第3の光入力ポートと第4の光出力ポートとの間で信号光を透過させ、かつ第1の光入力ポートと第2の光出力ポートとの間および第3の光入力ポートと第4の光出力ポートとの間を除く全ての光入力ポートと光出力ポートとの間で信号光を遮断するか、または第1の光入力ポートと第2の光出力ポートとの間および第4

の光入力ポートと第3の光出力ポートとの間で信号光を透過させ、かつ第1の光入力ポートと第2の光出力ポートとの間および第4の光入力ポートと第3の光出力ポートとの間を除く全ての光入力ポートと光出力ポートとの間で信号光を遮断するか、または第1の光入力ポートと第4の光出力ポートとの間および第3の光入力ポートと第2の光出力ポートとの間で信号光を透過させ、かつ第1の光入力ポートと第4の光出力ポートとの間および第3の光入力ポートと第2の光出力ポートとの間を除く全

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【0079】また更に、光クロスコネク用スイッチ回路S1-jの構成要素である2入力2出力クロス・バー動作光スイッチ回路CS-jは、特に2つの信号光ストリームのクロスコネクを制御するスイッチであり、このスイッチを特にマッハ・ツェンダ型平面導波路光LNスイッチ回路、ダブルゲートマッハ・ツェンダ型平面導波路光LNスイッチ回路、半導体光増幅器(SOA)型2×2光スイッチ回路のような高速な光スイッチングが実現可能な光スイッチ回路とすることにより、切り替え速度がnsecオーダーからsub-nsecオーダーの信号光パケット単位での高速な切り替えが実現できる。このとき、マッハ・ツェンダ型平面導波路光LNスイッチ回路、ダブルゲートマッハ・ツェンダ型平面導波路光LNスイッチ回路は挿入損失が比較的大きく、半導体光増幅器(SOA)型2×2光スイッチ回路はSOAのNFにより信号光を僅かながら劣化してしまうので、マッハ・ツェンダ型平面導波路光TOスイッチ回路またはダブル

ゲートマッハ・ツェンダ型平面導波路光TOSスイッチ回路を用いることにより、光クロスコネクタ用スイッチ回路S1-jの挿入損失、透過し信号光の劣化を抑えることができる。

【0080】次に、図4および図5を参照して、本発明の実施形態に係わる光バス・アレンジ用光回路および該光バス・アレンジ用光回路に使用されている光回路部CORE（光制御手段）の詳細について説明する。

【0081】図5に示す光回路部COREの例では、光波長合分波回路として、同一波長チャンネルの集合LO = $\{\lambda 4k + q + 1\}$ に対する波長合分波に関する集合を形成し、互いに素である4つの光入出力ポートの集合

【数7】 $PG-1 = A-3 = \{L-P, q, R-P, 4K + q + 1\}$,

$PG-2 = A-1 = \{L-P, q-1, R-P, 4K + q + 2\}$,

$PG-3 = A-4 = \{L-P, q+1, R-P, 4K + q\}$,

$PG-4 = A-2 = \{L-P, q-2, R-P, 4K + q + 3\}$,

を有するN×N AWG WM-1と、前記波長チャンネル

【表4(a)】

$q-4m < 1$ の場合

	L-P, q+1	L-P, q	L-P, q-1	L-P, q-2	
$\lambda q-4m+5$	R-P, q-4m+4	R-P, q-4m+5	R-P, q-4m+6	R-P, q-4m+7	
\vdots	\vdots	\vdots	\vdots	\vdots	
$\lambda q-3$	R-P, q-4	R-P, q-3	R-P, q-2	R-P, q-1	
$\lambda q+1$	R-P, q	R-P, q+1	R-P, q+2	R-P, q+3	
$\lambda q+5$	R-P, q+4	R-P, q+5	R-P, q+6	R-P, q+7	
\vdots	\vdots	\vdots	\vdots	\vdots	
$\lambda q+4m-3$	R-P, q+4m-4	R-P, q+4m-3	R-P, q+4m-2	R-P, q+4m-1	

【表7】

【表4(b)】

$1 \leq q-4m < 3$ の場合

	L-P, q+1	L-P, q	L-P, q-1	L-P, q-2	
$\lambda q-4m+1$	R-P, q-4m	R-P, q-4m+1	R-P, q-4m+2	R-P, q-4m+3	
\vdots	\vdots	\vdots	\vdots	\vdots	
$\lambda q-3$	R-P, q-4	R-P, q-3	R-P, q-2	R-P, q-1	
$\lambda q+1$	R-P, q	R-P, q+1	R-P, q+2	R-P, q+3	
$\lambda q+5$	R-P, q+4	R-P, q+5	R-P, q+6	R-P, q+7	
\vdots	\vdots	\vdots	\vdots	\vdots	
$\lambda q+4m-3$	R-P, q+4m-4	R-P, q+4m-3	R-P, q+4m-2	R-P, q+4m-1	

【表8】

*ネルの集合LOに対する波長合分波に関する集合を形成し、互いに素である4つの光入出力ポートの集合

【数8】 $PG-5 = A-7 = \{L-P, q, R-P, 4K + q + 1\}$,

$PG-6 = A-5 = \{L-P, q-1, R-P, 4K + q + 2\}$,

$PG-7 = A-8 = \{L-P, q+1, R-P, 4K + q\}$,

$PG-8 = A-6 = \{L-P, q-2, R-P, 4K + q + 3\}$,

を有するN×N AWG WM-2とからなる計2つのN×N AWGを用いて構成されている。

【0082】なお、透過波長チャンネルに対しての光入出力ポートの対応表として次に示す表4a、表4

(b)、表4(c)、表4(d)、表4(e)を参照されたい。表4(a)は $q-4m < 2$ の場合であり、表4

(b)は $1 \leq q-4m < 3$ の場合であり、表4(c)は $q-4m = 3$ の場合であり、表4(d)は $q-4m =$

0、 $N = 2q$ で完全周回特性を有する場合であり、表4

eは $N = 32$ の場合の具体例である。

【0083】

【表6】

【表4(c)】

q-4m=3の場合

	L-P. q+1	L-P. q	L-P. q-1	L-P. q-2	
$\lambda q-4m+1$	R-P. q-4m	R-P. q-4m+1	R-P. q-4m+2	R-P. q-4m+3	
\vdots	\vdots	\vdots	\vdots	\vdots	
$\lambda q-3$	R-P. q-4	R-P. q-3	R-P. q-2	R-P. q-1	
$\lambda q+1$	R-P. q	R-P. q+1	R-P. q+2	R-P. q+3	
$\lambda q+5$	R-P. q+4	R-P. q+5	R-P. q+6	R-P. q+7	
\vdots	\vdots	\vdots	\vdots	\vdots	
$\lambda q+4m-3$	R-P. q+4m-4	R-P. q+4m-3	R-P. q+4m-2	R-P. q+4m-1	
$\lambda q+4m+1$	R-P. q+4m	R-P. q+4m+1	R-P. q+4m+2	R-P. q+4m+3	

【表9】

【表4(d)】

N=2q且つq-4m=0且つ完全周回特性を持つ場合

	L-P. q+1	L-P. q	L-P. q-1	L-P. q-2	
$\lambda q-4m+1$	R-P. q-4m	R-P. q-4m+1	R-P. q-4m+2	R-P. q-4m+3	
\vdots	\vdots	\vdots	\vdots	\vdots	
$\lambda q-3$	R-P. q-4	R-P. q-3	R-P. q-2	R-P. q-1	
$\lambda q+1$	R-P. q	R-P. q+1	R-P. q+2	R-P. q+3	
$\lambda q+5$	R-P. q+4	R-P. q+5	R-P. q+6	R-P. q+7	
\vdots	\vdots	\vdots	\vdots	\vdots	
$\lambda q+4m-3$	R-P. q+4m-4	R-P. q+4m-3	R-P. q+4m-2	R-P. q+4m-1	

【表10】

【表4(e)】

32×32 AWG, q-4m=0, で完全周回特性を持つ場合の具体例

	L-P. 17	L-P. 16	L-P. 15	L-P. 14	
$\lambda 1$	R-P. 32	R-P. 1	R-P. 2	R-P. 3	
\vdots	\vdots	\vdots	\vdots	\vdots	
$\lambda 14$	R-P. 12	R-P. 16	R-P. 14	R-P. 15	
$\lambda 17$	R-P. 16	R-P. 17	R-P. 18	R-P. 16	
$\lambda 21$	R-P. 26	R-P. 21	R-P. 22	R-P. 23	
\vdots	\vdots	\vdots	\vdots	\vdots	
$\lambda 29$	R-P. 28	R-P. 29	R-P. 30	R-P. 31	

但し、ここで、 $m = \text{int}(q/4)$ 、 $q = \text{int}(N/2)$ であり、 $q-4m < 1$ のとき、 $k = -m+1, \dots, -1, 0, \dots, m-1$ であり、 $1 \leq q-4m < 3$ のとき、または $q-6m=0$ 、 $N=2q$ かつ完全周回特性を有するとき、 $k = -m, -m+1, \dots, -1, 0, 1, \dots, m-1$ であり、 $q-6m=3$ のとき、 $k = -m, -m+1, \dots, -1, 0, 1, \dots, m-1, m$ である。

【0084】更に、光入出力ポートA-1/O-1、A-1/O-2、A-1/O-3、およびA-1/O-4と光合分波回路N×N AWG WM-1の合波側の光入出力ポートL-P. q、L-P. q+1、L-P. q-1、およびL-P. q-2とはそれぞれ同一の光入出力ポートを表し、かつ光入出力ポートA-1/O-d-1-i、A-1/O-d-2-i、A-1/O-d-

3-i、およびA-1/O-d-4-iと光合分波回路N×N AWG WM-1の分波側の光入出力ポートR-P. i+1、R-P. i、R-P. i+2、およびR-P. i+3とはそれぞれ同一の光入出力ポートを表し、かつ光入出力ポートA-1/O-5、A-1/O-6、A-1/O-7、およびA-1/O-8と光合分波回路N×N AWG WM-2の合波側の光入出力ポートR-P. q、R-P. q+1、R-P. q-1、およびR-P. q-2とはそれぞれ同一の光入出力ポートを表し、かつ光入出力ポートA-1/O-d-5-i、A-1/O-d-6-i、A-1/O-d-7-i、およびA-1/O-d-8-iと光合分波回路N×N AWG WM-2の分波側の光入出力ポートL-P. i+1、L-P. i、L-P. i+2、およびL-P. i+3とはそれぞれ同一の光入出力ポートを表すものとす

る。

【0085】上述したように光入出力ポートの組合せを選択することにより、表4a、b、c、dおよび図5から分かるように、光入出力ポートの集合PG-n ($n=1, 2, 3, 4$)の同じ波長チャンネルに対応する分波側の入出力ポート、ならびに光入出力ポートの集合PG-n ($n=5, 6, 7, 8$)の同じ波長チャンネルに対応する分波側の入出力ポートは配置上その他の光入出力ポートを中に入り込ませずに一団を形成させることが可能となる。

【0086】従って、 $N \times N$ AWG WM-1のL0に対する波長合分波に関する入出力ポートの集合PG-n ($n=1, 2, 3, 4$)の同じ波長チャンネルに対応する分波側の光入出力ポートR-P. $6k+q+1$, R-P. $6k+q$, R-P. $6k+q+2$, 及びR-P. $6k+q+3$ と、各波長チャンネルにそれぞれ対応して個別に配置され、かつ波長チャンネル毎にそれらの何れかが配置されるところの光クロスコネク用スイッチ回路S1-j, SP-j, ($j=4k+q+1$)および光回路S3-jの光入力ポートS-j-1-1, S-j-1-2, S-j-1-3, 及びS-j-1-4とをそれぞれ光導波路で結び、かつ、 $N \times N$ AWG WM-2のL0に対する波長合分波に関する入出力ポートの集合P-n ($n=7, 8, \dots, 12$)の同じ波長チャンネルに対応する分波側の光入出力ポートL-P. $6k+q+1$, L-P. $6k+q$, L-P. $6k+q+2$, 及びL-P. $6k+q+3$ と、各波長チャンネルにそれぞれ対応して個別に配置され、かつ波長チャンネル毎にそれらの何れかが配置されるところの光クロスコネク用スイッチ回路S1-j, SP-j, ($j=4k+q+1$)および光回路S3-jの光出力ポートS-j-O-1, S-j-O-2, S-j-O-3, 及びS-j-O-4とをそれぞれ光導波路で結び回路配置にすることにより光合分波回路 $N \times N$ AWG WM-1, WM-2、と各波長チャンネルにそれぞれ対応して個別に配置され、か

つ波長チャンネル毎にそれらの何れかが配置されるところの各クロスコネク用スイッチ回路S1-j, SP-j, ($j=4k+q+1$)および光回路S3-jの入出力ポート間を結ぶ光導波路を全て交差させることなく、これらの光回路を同一平面上に配置・作成する事が可能である。

【0087】光導波路の交差部は、それぞれの光導波路間のクロストーク、および交差する構造による損失の増加を抑え作成する事が可能であるが、クロストークを完全に零とすること、および交差する構造による損失の増加を完全に零にすることは現実の作成上困難であるため、本発明の、光合分波回路 $N \times N$

AWG WM-1, WM-2と各波長チャンネルにそれぞれ対応して個別に配置され、かつ波長チャンネル毎にそれらの何れかが配置されるところの光クロスコネク用スイッチ回路S1-j, SP-j, ($j=4k+q+1$)および光回路S3-jの入出力ポート間を結ぶ光導波路の配置構成は、一つの平面基板上に回路を集積化して作成する場合、及び光合分波回路 $N \times N$ AWG WM-1, WM-2と光クロスコネク用スイッチ回路S1-j, 或いは、SP-jをそれぞれ個別に平面基板光回路として作成し、それぞれの光入出力ポートを付

き合わせ接続する事により全体の回路を構成する場合 (I. Ogawa et. al, OFC'98 PD4-1), 光導波路の交差構造に起因するクロストーク及び損失を完全に零にすることが出来、有利である。

【0088】さらに、光回路部COREの光入出力ポート間におけるそれぞれの波長チャンネルでの透過・遮断特性と、それぞれの波長チャンネルに対応して配置された光クロスコネク用スイッチ回路S1-j, SP-j, ($j=4k+q+1$)のスイッチ状態との間にはそれぞれ表5(a)及び表5(b)に示すような対応関係が成立する。

【0089】

【表11】

【表5(a)】

No.	光クロスコネク用スイッチ回路 のスイッチ動作状態	光回路部COREの光入出力ポート間での 信号光の通過・遮断特性
1	S-J-1-1, S-J-0-2間, S-J-1-2, S-J-0-4間が通過 且つ S-J-1-1, S-J-0-2間, S-J-1-3, S-J-0-4間 を除く全ての入出力ポート間が遮断	A-1/0-1, A-1/0-6間, A-1/0-2, A-1/0-5間が通過 且つ A-1/0-1, A-1/0-6間, A-1/0-3, A-1/0-6間 を除く全ての入出力ポート間が遮断
2	S-J-1-1, S-J-0-2間, S-J-1-4, S-J-0-3間 が通過 且つ S-J-1-1, S-J-0-2間, S-J-1-4, S-J-0-3間 を除く全ての入出力ポート間が遮断	A-1/0-1, A-1/0-6間, A-1/0-4, A-1/0-7間が通過 且つ A-1/0-1, A-1/0-6間, A-1/0-4, A-1/0-7間 を除く全ての入出力ポート間が遮断
3	S-J-1-1, S-J-0-1間, S-J-1-3, S-J-0-2間が通過 且つ S-J-1-1, S-J-0-1間, S-J-1-3, S-J-0-2間 を除く全ての入出力ポート間が遮断	A-1/0-1, A-1/0-6間, A-1/0-3, A-1/0-6間が通過 且つ A-1/0-1, A-1/0-6間, A-1/0-3, A-1/0-6間 を除く全ての入出力ポート間が遮断
4	S-J-1-1, S-J-0-3間, S-J-1-4, S-J-0-2間が通過 且つ S-J-1-1, S-J-0-3間, S-J-1-4, S-J-0-2間 を除く全ての入出力ポート間が遮断	A-1/0-1, A-1/0-7間, A-1/0-4, A-1/0-6間が通過 且つ A-1/0-1, A-1/0-7間, A-1/0-4, A-1/0-6間 を除く全ての入出力ポート間が遮断
5	S-J-1-2, S-J-0-1間, S-J-1-3, S-J-0-4間が通過 且つ S-J-1-2, S-J-0-1間, S-J-1-3, S-J-0-4間 を除く全ての入出力ポート間が遮断	A-1/0-2, A-1/0-5間, A-1/0-3, A-1/0-6間が通過 且つ A-1/0-2, A-1/0-5間, A-1/0-3, A-1/0-6間 を除く全ての入出力ポート間が遮断
6	S-J-1-2, S-J-0-1間, S-J-1-4, S-J-0-3間が通過 且つ S-J-1-2, S-J-0-1間, S-J-1-4, S-J-0-3間 を除く全ての入出力ポート間が遮断	A-1/0-2, A-1/0-6間, A-1/0-4, A-1/0-7間が通過 且つ A-1/0-2, A-1/0-6間, A-1/0-4, A-1/0-7間 を除く全ての入出力ポート間が遮断
7	S-J-1-2, S-J-0-4間, S-J-1-3, S-J-0-1間が通過 且つ S-J-1-2, S-J-0-4間, S-J-1-3, S-J-0-1間 を除く全ての入出力ポート間が遮断	A-1/0-2, A-1/0-6間, A-1/0-3, A-1/0-6間が通過 且つ A-1/0-2, A-1/0-6間, A-1/0-3, A-1/0-6間 を除く全ての入出力ポート間が遮断
8	S-J-1-2, S-J-0-3間, S-J-1-4, S-J-0-1間が通過 且つ S-J-1-2, S-J-0-3間, S-J-1-4, S-J-0-1間 を除く全ての入出力ポート間が遮断	A-1/0-2, A-1/0-7間, A-1/0-4, A-1/0-6間が通過 且つ A-1/0-2, A-1/0-7間, A-1/0-4, A-1/0-6間 を除く全ての入出力ポート間が遮断

【表12】

【表5(b)】

No.	光クロスコネク用スイッチ回路のスイッチ動作状態	光回路部COREの光入出力ポート間での信号光の透過・遮断特性
1	S-j-1, S-j-2, S-j-3, S-j-4間が透過 且つ S-j-1, S-j-2, S-j-3, S-j-4間 を除く全ての入出力ポート間が遮断	A-1/O-1, A-1/O-2, A-1/O-3, A-1/O-4間が透過 且つ A-1/O-1, A-1/O-2, A-1/O-3, A-1/O-4間 を除く全ての入出力ポート間が遮断
2	S-j-1, S-j-2, S-j-3, S-j-4間が透過 且つ S-j-1, S-j-2, S-j-3, S-j-4間 を除く全ての入出力ポート間が遮断	A-1/O-1, A-1/O-2, A-1/O-3, A-1/O-4間が透過 且つ A-1/O-1, A-1/O-2, A-1/O-3, A-1/O-4間 を除く全ての入出力ポート間が遮断
3	S-j-1, S-j-2, S-j-3, S-j-4間が透過 且つ S-j-1, S-j-2, S-j-3, S-j-4間 を除く全ての入出力ポート間が遮断	A-1/O-1, A-1/O-2, A-1/O-3, A-1/O-4間が透過 且つ A-1/O-1, A-1/O-2, A-1/O-3, A-1/O-4間 を除く全ての入出力ポート間が遮断
4	S-j-1, S-j-2, S-j-3, S-j-4間が透過 且つ S-j-1, S-j-2, S-j-3, S-j-4間 を除く全ての入出力ポート間が遮断	A-1/O-1, A-1/O-2, A-1/O-3, A-1/O-4間が透過 且つ A-1/O-1, A-1/O-2, A-1/O-3, A-1/O-4間 を除く全ての入出力ポート間が遮断
5	S-j-1, S-j-2, S-j-3, S-j-4間が透過 且つ S-j-1, S-j-2, S-j-3, S-j-4間 を除く全ての入出力ポート間が遮断	A-1/O-1, A-1/O-2, A-1/O-3, A-1/O-4間が透過 且つ A-1/O-1, A-1/O-2, A-1/O-3, A-1/O-4間 を除く全ての入出力ポート間が遮断
6	S-j-1, S-j-2, S-j-3, S-j-4間が透過 且つ S-j-1, S-j-2, S-j-3, S-j-4間 を除く全ての入出力ポート間が遮断	A-1/O-1, A-1/O-2, A-1/O-3, A-1/O-4間が透過 且つ A-1/O-1, A-1/O-2, A-1/O-3, A-1/O-4間 を除く全ての入出力ポート間が遮断
7	S-j-1, S-j-2, S-j-3, S-j-4間が透過 且つ S-j-1, S-j-2, S-j-3, S-j-4間 を除く全ての入出力ポート間が遮断	A-1/O-1, A-1/O-2, A-1/O-3, A-1/O-4間が透過 且つ A-1/O-1, A-1/O-2, A-1/O-3, A-1/O-4間 を除く全ての入出力ポート間が遮断
8	S-j-1, S-j-2, S-j-3, S-j-4間が透過 且つ S-j-1, S-j-2, S-j-3, S-j-4間 を除く全ての入出力ポート間が遮断	A-1/O-1, A-1/O-2, A-1/O-3, A-1/O-4間が透過 且つ A-1/O-1, A-1/O-2, A-1/O-3, A-1/O-4間 を除く全ての入出力ポート間が遮断
9	S-j-1, S-j-2, S-j-3, S-j-4間が透過 且つ S-j-1, S-j-2, S-j-3, S-j-4間 を除く全ての入出力ポート間が遮断	A-1/O-1, A-1/O-2, A-1/O-3, A-1/O-4間が透過 且つ A-1/O-1, A-1/O-2, A-1/O-3, A-1/O-4間 を除く全ての入出力ポート間が遮断
10	S-j-1, S-j-2, S-j-3, S-j-4間が透過 且つ S-j-1, S-j-2, S-j-3, S-j-4間 を除く全ての入出力ポート間が遮断	A-1/O-1, A-1/O-2, A-1/O-3, A-1/O-4間が透過 且つ A-1/O-1, A-1/O-2, A-1/O-3, A-1/O-4間 を除く全ての入出力ポート間が遮断
11	S-j-1, S-j-2, S-j-3, S-j-4間が透過 且つ S-j-1, S-j-2, S-j-3, S-j-4間 を除く全ての入出力ポート間が遮断	A-1/O-1, A-1/O-2, A-1/O-3, A-1/O-4間が透過 且つ A-1/O-1, A-1/O-2, A-1/O-3, A-1/O-4間 を除く全ての入出力ポート間が遮断
12	S-j-1, S-j-2, S-j-3, S-j-4間が透過 且つ S-j-1, S-j-2, S-j-3, S-j-4間 を除く全ての入出力ポート間が遮断	A-1/O-1, A-1/O-2, A-1/O-3, A-1/O-4間が透過 且つ A-1/O-1, A-1/O-2, A-1/O-3, A-1/O-4間 を除く全ての入出力ポート間が遮断

さらに、本発明の光バス・アレイ用光回路の光入出力ポートI/O-n (n=1, 2, 3, 4)と、光サーキュレータCL-n (n=1, 2, 3, 4)の光入出力ポートCL-I/O-n (n=1, 2, 3, 4)とを光導波路でそれぞれ結び、かつ光サーキュレータCL-n (n=1, 2, 3, 4)の光出力ポートCL-O-n (n=1, 2, 3, 4)と、光回路部COREの光入出力ポートA-I/O-n (n=1, 2, 3, 4)との間に、光出力ポートCL-O-nから光出力ポートA-I/O-nへ伝搬する方向に光増幅される向きに従来型の

片方向光増幅器AMP-n (n=1, 2, 3, 4)がそれぞれ接続され、かつ光回路部COREの光出力ポートA-I/O-n (n=5, 6, 7, 8)と、光サーキュレータCL-n (n=1, 2, 3, 4)の光入力ポートCL-I-n (n=1, 2, 3, 4)とを光導波路でそれぞれ結ぶことにより、光クロスコネク用スイッチ回路S1-j, 及びSP-j (j=4k+q+1)をそれぞれ用いた場合の光回路部COREの光入出力ポート間における各波長チャンネルでの透過・遮断特性と、本発明の光バス・アレイ用光回路のそれぞれ対応する波長

チャンネルにおける外部入出力ポート I/O-n (n = * する。
1, 2, 3, 4) 間の信号光の光伝播増幅状態との間に 【表13】
はそれぞれ表6 a. 及び表6 b. に示す対応関係が成立*

【表6(a)】

No.	光回路部COREの光入出力ポート間での 信号光の透過・遮断特性	光バス・アレイ用光回路 の光伝播増幅状態
1	A-1/O-1, A-1/O-6間、A-1/O-2, A-1/O-5間が透過 且つ A-1/O-1, A-1/O-6間、A-1/O-3, A-1/O-4間 を除く全ての入出力ポート間が遮断	I/O-1 ⇒ I/O-2, I/O-3 ⇒ I/O-4
2	A-1/O-1, A-1/O-6間、A-1/O-4, A-1/O-7間が透過 且つ A-1/O-1, A-1/O-6間、A-1/O-2, A-1/O-3間 を除く全ての入出力ポート間が遮断	I/O-1 ⇒ I/O-2, I/O-4 ⇒ I/O-3
3	A-1/O-1, A-1/O-6間、A-1/O-3, A-1/O-8間が透過 且つ A-1/O-1, A-1/O-6間、A-1/O-2, A-1/O-4間 を除く全ての入出力ポート間が遮断	I/O-1 ⇒ I/O-4, I/O-3 ⇒ I/O-2
4	A-1/O-1, A-1/O-7間、A-1/O-4, A-1/O-8間が透過 且つ A-1/O-1, A-1/O-7間、A-1/O-2, A-1/O-3間 を除く全ての入出力ポート間が遮断	I/O-1 ⇒ I/O-3, I/O-4 ⇒ I/O-2
5	A-1/O-2, A-1/O-5間、A-1/O-3, A-1/O-6間が透過 且つ A-1/O-2, A-1/O-5間、A-1/O-4, A-1/O-7間 を除く全ての入出力ポート間が遮断	I/O-2 ⇒ I/O-1, I/O-3 ⇒ I/O-4
6	A-1/O-2, A-1/O-5間、A-1/O-4, A-1/O-7間が透過 且つ A-1/O-2, A-1/O-5間、A-1/O-3, A-1/O-6間 を除く全ての入出力ポート間が遮断	I/O-2 ⇒ I/O-4, I/O-4 ⇒ I/O-3
7	A-1/O-2, A-1/O-6間、A-1/O-3, A-1/O-8間が透過 且つ A-1/O-2, A-1/O-6間、A-1/O-4, A-1/O-7間 を除く全ての入出力ポート間が遮断	I/O-2 ⇒ I/O-1, I/O-3 ⇒ I/O-4
8	A-1/O-2, A-1/O-7間、A-1/O-4, A-1/O-8間が透過 且つ A-1/O-2, A-1/O-7間、A-1/O-3, A-1/O-5間 を除く全ての入出力ポート間が遮断	I/O-2 ⇒ I/O-3, I/O-4 ⇒ I/O-1

【表14】

【表6(b)】

No.	光回路部009Eの入出力ポート間での 信号光の透過・遮断特性	光バス・アレイ用光回路 の光伝搬増幅状態
1	$\lambda=1/0-1, \lambda=1/0-6$ 間、 $\lambda=1/0-2, \lambda=1/0-8$ 間が透過 且つ $\lambda=1/0-1, \lambda=1/0-4$ 間、 $\lambda=1/0-3, \lambda=1/0-7$ 間 を除く全ての入出力ポート間が遮断	$1/0-1 \Rightarrow 1/0-2, 1/0-3 \Rightarrow 1/0-4$
2	$\lambda=1/0-1, \lambda=1/0-6$ 間、 $\lambda=1/0-4, \lambda=1/0-7$ 間が透過 且つ $\lambda=1/0-1, \lambda=1/0-8$ 間、 $\lambda=1/0-2, \lambda=1/0-3$ 間 を除く全ての入出力ポート間が遮断	$1/0-1 \Rightarrow 1/0-2, 1/0-4 \Rightarrow 1/0-3$
3	$\lambda=1/0-1, \lambda=1/0-6$ 間、 $\lambda=1/0-2, \lambda=1/0-8$ 間が透過 且つ $\lambda=1/0-1, \lambda=1/0-4$ 間、 $\lambda=1/0-3, \lambda=1/0-7$ 間 を除く全ての入出力ポート間が遮断	$1/0-1 \Rightarrow 1/0-4, 1/0-3 \Rightarrow 1/0-2$
4	$\lambda=1/0-1, \lambda=1/0-6$ 間、 $\lambda=1/0-4, \lambda=1/0-8$ 間が透過 且つ $\lambda=1/0-1, \lambda=1/0-7$ 間、 $\lambda=1/0-2, \lambda=1/0-3$ 間 を除く全ての入出力ポート間が遮断	$1/0-1 \Rightarrow 1/0-3, 1/0-4 \Rightarrow 1/0-2$
5	$\lambda=1/0-2, \lambda=1/0-8$ 間、 $\lambda=1/0-1, \lambda=1/0-6$ 間が透過 且つ $\lambda=1/0-2, \lambda=1/0-4$ 間、 $\lambda=1/0-3, \lambda=1/0-7$ 間 を除く全ての入出力ポート間が遮断	$1/0-2 \Rightarrow 1/0-1, 1/0-3 \Rightarrow 1/0-4$
6	$\lambda=1/0-2, \lambda=1/0-8$ 間、 $\lambda=1/0-4, \lambda=1/0-7$ 間が透過 且つ $\lambda=1/0-2, \lambda=1/0-6$ 間、 $\lambda=1/0-1, \lambda=1/0-3$ 間 を除く全ての入出力ポート間が遮断	$1/0-2 \Rightarrow 1/0-1, 1/0-4 \Rightarrow 1/0-3$
7	$\lambda=1/0-2, \lambda=1/0-8$ 間、 $\lambda=1/0-1, \lambda=1/0-6$ 間が透過 且つ $\lambda=1/0-2, \lambda=1/0-4$ 間、 $\lambda=1/0-3, \lambda=1/0-7$ 間 を除く全ての入出力ポート間が遮断	$1/0-2 \Rightarrow 1/0-4, 1/0-3 \Rightarrow 1/0-1$
8	$\lambda=1/0-2, \lambda=1/0-8$ 間、 $\lambda=1/0-4, \lambda=1/0-7$ 間が透過 且つ $\lambda=1/0-2, \lambda=1/0-6$ 間、 $\lambda=1/0-1, \lambda=1/0-3$ 間 を除く全ての入出力ポート間が遮断	$1/0-2 \Rightarrow 1/0-3, 1/0-4 \Rightarrow 1/0-1$
9	$\lambda=1/0-1, \lambda=1/0-6$ 間、 $\lambda=1/0-2, \lambda=1/0-8$ 間が透過 且つ $\lambda=1/0-1, \lambda=1/0-4$ 間、 $\lambda=1/0-3, \lambda=1/0-7$ 間 を除く全ての入出力ポート間が遮断	$1/0-1 \Rightarrow 1/0-3, 1/0-2 \Rightarrow 1/0-4$
10	$\lambda=1/0-1, \lambda=1/0-6$ 間、 $\lambda=1/0-2, \lambda=1/0-8$ 間が透過 且つ $\lambda=1/0-1, \lambda=1/0-4$ 間、 $\lambda=1/0-3, \lambda=1/0-7$ 間 を除く全ての入出力ポート間が遮断	$1/0-1 \Rightarrow 1/0-4, 1/0-2 \Rightarrow 1/0-3$
11	$\lambda=1/0-2, \lambda=1/0-8$ 間、 $\lambda=1/0-4, \lambda=1/0-7$ 間が透過 且つ $\lambda=1/0-2, \lambda=1/0-6$ 間、 $\lambda=1/0-1, \lambda=1/0-3$ 間 を除く全ての入出力ポート間が遮断	$1/0-3 \Rightarrow 1/0-1, 1/0-4 \Rightarrow 1/0-2$
12	$\lambda=1/0-2, \lambda=1/0-8$ 間、 $\lambda=1/0-1, \lambda=1/0-6$ 間が透過 且つ $\lambda=1/0-2, \lambda=1/0-4$ 間、 $\lambda=1/0-3, \lambda=1/0-7$ 間 を除く全ての入出力ポート間が遮断	$1/0-3 \Rightarrow 1/0-2, 1/0-4 \Rightarrow 1/0-1$

従って、それぞれの波長チャンネルに対応して個別に配
置された何れかの光クロスコネク用スイッチ回路S1
-j、及び、SP-j (j=4k+q+1) のスイッチ
状態を制御する事により表5(a)と表6(a)間、及
び表5(b)と表6(b)間、間にそれぞれ示す対応関係に従い
本発明のバス・アレイ用光回路のそれぞれの対応する
波長チャンネルにおける外部入出力ポート1/O-n
(n=1, 2, 3, 4)間の光伝搬増幅状態を制御する
ことができる。

【0090】すなわち、それぞれ2つずつ外部光入力ポ

ートおよび外部光出力ポートを有する従来の光クロスコ
ネク用回路は、図6に示すように、クロス、バーの2種
類の光伝搬増幅状態を切り替え制御できるのみであるの
に対して本発明の光バス・アレイ用光回路では、光ク
ロスコネク用スイッチ回路S1-jを用いた場合、ク
ロス・バーの光伝搬増幅状態の切り替え制御に加えて、
外部光入出力ポート1/O-1、1/O-2間と1/O
-3、1/O-4間それぞれにおいて波長チャンネル毎
に個別の上り下りの2つの光伝搬増幅方向の動的切り替
え制御が可能となるため、図7に示すような8通りの光

【0093】また、現実のネットワークにおいて、いくつかの波長チャンネルのパスは固定で使うことが決まっている場合、前記光クロスコネク用スイッチ回路S1-jおよび光クロスコネク用スイッチSP-jに替えて、光回路S3-j、すなわち第1乃至第4の光入力ポートおよび第1乃至第4の光出力ポートを有し、第1の光入力ポートと第2の光出力ポートとの間および第3の光入力ポートと第4の光出力ポートとの間で光導波路を結び、その他のすべての光入力ポートと光出力ポートを終端するか、または第1の光入力ポートと第2の光出力ポートとの間および第4の光入力ポートと第3の光出力ポートとの間で光導波路を結び、その他のすべての光入力ポートと光出力ポートを終端するか、または第1の光入力ポートと第3の光出力ポートとの間および第4の光入力ポートと第2の光出力ポートとの間で光導波路を結び、その他のすべての光入力ポートと光出力ポートを終端するか、または第2の光入力ポートと第1の光出力ポートとの間および第3の光入力ポートと第4の光出力ポートとの間で光導波路を結び、その他のすべての光入力ポートと光出力ポートを終端するか、または第2の光入力ポートと第3の光出力ポートとの間および第4の光入力ポートと第1の光出力ポートとの間で光導波路を結び、その他のすべての光入力ポートと光出力ポートを終端するか、または第1の光入力ポートと第3の光出力ポートとの間および第2の光入力ポートと第4の光出力ポートとの間で光導波路を結

【0096】更に、上述した図5のように、光波長合分波回路として、 $N \times N$ AWGを用いると、光波長合分波回路一つ当たりの光損失は、理想的には1.0 dB程度。(J.C.Chen, et. al, IEEE PTL, vol. 10, No. 3, pp379-381, 1998). ダブルゲートマッハ・ツェンダ型平面導波路光TOSスイッチ回路を用いた場合の光クロスコネク用回路S1-j, SP-jの損失が5 dB未満 (A. Himeeno, et. al, ECOC'96TH0.2.2). 半導体光増幅器(SOA)型 2×2 光スイッチ回路を用いた場合は光クロスコネク用回路S1-j, SP-jの損失が0 dB (I. Ogawa et. al, OFC'98PD4-1). 光サーキュレータの損失が一回透過する毎に1 dB程度、光ファイバへの結合一つ当たりの損失が、およそ0.25 dB、さらに回路接続用の光ファイバが十分短いものとして、その損失を無視できるものと見做もわれ、見、光増幅器の光増幅利得を入力値強度-20 dBmのとき、およそ30 dB (橋本他1995秋季学会論文集C-216)と見做ると、光バス・アレーン用光回路の正味の光増幅利得は、

【数9】 $30-1.0 \times 2-5.0(0)-1.0 \times 2-0.25 \times 4=30-10=20(25) \text{ dB}$

と見積もられる。従って、中継間隔80km平均光ファイバ損失0.23dB/kmの光伝送システムでの各区間の損失18.4dBを保證する事が可能となる。

【0097】また、 $N \times N$ AWGの漏話量は、通常のものがおよそ25dB、位相補償板を用いた低いクロストーク化を図ったものでおよそ40dB、(山田他1997秋季信学会論文集C-3-119)と見積もられ、さらに光アイソレータのアイソレーションをおよそ40dB、光サークキュレータのアイソレーションをおよそ50dBと見積もらると、任意の波長チャンネルでの発振は通常の光増幅器と同様に抑えられる。

【0098】また、光増幅器外部の前後に近接して存在する二つのフレネル反射(-14dB)点と伝播方向の異なる任意の二つの波長チャンネルでループ状に構成される光共振器を想定すると、

【数10】 30×2 (共振器一往復当たりの光増幅部の利得) - $\{14 + 1.0 \times 2 + 25(40) \times 2\} \times 2$ (共振器一往復当たりの光損失) = $72[-132]$ dB

と見積もられ、圧倒的に共振器内部損失が大きく正味の利得が得られないので、このような最悪の場合であっても本実施形態における光増幅器の発振は抑えられる。

【0099】上述したように、本実施形態の光パス・アレンジ用光回路により、光ファイバ中をそれぞれ波長チャンネル毎に上りおよび下り方向に関して任意の伝播方向に伝播し、かつそれぞれの波長チャンネル毎に必要に応じて各々の伝播方向を上りから下りにまたは下りから上りに切り替えるといった動的な変化を伴う2つのストリームに属する波長多量信号光をその時々に応じて信号光の伝播方向へのアイソレーションを確保しつつ光増幅し、かつ各波長チャンネル毎に光クロスコネクタを行うことにより実現される図7に示す8通りの光伝播増幅状態を実現することができるとともに、また各波長チャンネル毎に4つの信号光入出力ポートに対してそれぞれ重複しない範囲で任意に入出力ポートを選択して、信号光を入出力させ、2つの信号光ストリームを伝播増幅させる全ての組合せである図8に示す12通りの光伝播増幅状態を実現することができる。

【0100】

【発明の効果】以上説明したように、本発明によれば、光ファイバ中をそれぞれ波長チャンネル毎に上りおよび下り方向に関して任意の伝播方向に伝播し、かつそれぞれの波長チャンネル毎に必要に応じて各々の伝播方向を上りから下りにまたは下りから上りに切り替えるといった動的な変化を伴う2つのストリームに属する波長多量信号光をその時々に応じて信号光の伝播方向へのアイソレーションを確保しつつ光増幅し、かつ各波長チャンネル毎に光クロスコネクタを行うことにより実現される8通りの光伝播増幅状態を実現することができる。

【0101】また、本発明によれば、各波長チャンネル

毎に4つの信号光入出力ポートに対してそれぞれ重複しない範囲で任意に入出力ポートを選択して、信号光を入出力させ、2つの信号光ストリームを伝播増幅させる全ての組合せである12通りの光伝播増幅状態を実現することができる。

【図面の簡単な説明】

【図1】アレー導波路型光合分波器の構成を示す図である。

【図2】本発明の一実施形態に使用される光クロスコネクタ用スイッチ回路S1-jの構成を示す図である。

【図3】本発明の一実施形態に使用される光クロスコネクタ用スイッチSP-jの構成を示す図である。

【図4】本発明の一実施形態に係わる光パス・アレンジ用光回路の構成を示す図である。

【図5】図4に示す光パス・アレンジ用光回路に使用されている光回路部COREの詳細な構成を示す図である。

【図6】従来の光クロスコネクタ回路が実現する各光入出力ポートおよび光出力ポート間での2つの光伝播増幅状態を示す模式図である。

【図7】本発明の光パス・アレンジ用光回路が実現する各光入出力ポート間での代表的な8つの光伝播増幅状態(光クロスコネクタ用スイッチ回路S1-jおよび光クロスコネクタ用スイッチSP-jを用いた場合)を示す模式図である。

【図8】本発明の光パス・アレンジ用光回路が実現する各光入出力ポート間での代表的な12の光伝播増幅状態(光クロスコネクタ用スイッチSP-jを用いた場合)を示す模式図である。

【図9】従来の光クロスコネクタ回路の構成を示す図である。

【図10】従来の光アド・ドロップ回路の構成を示す図である。

【図11】従来の片方向光増幅器の構成を示す図である。

【図12】光増幅器の構成を示す図である。

【符号の説明】

0-1, 0-3, 0-3-i (i=1, 2, ..., n)

外部入力ポート

0-2, 0-4, 0-4-i (i=1, 2, ..., n)

外部出力ポート

1-i (i=1, 2, 3, 4) 光増幅器

1-i-1 光増幅部

1-i-2-1, 1-i-2-2 光アイソレータ

2-i (i=1, 2, 3, 4) 光合波長合分波器

3-i (i=1, 2, ..., n) 2入力2出力クロス・バー動作光スイッチ回路

4 巻土類添加光ファイバ

5-1, 5-2 励起用レーザー

6-1, 6-2 光アイソレータ

7-1, 7-2 波長台分波カプラ

8 平面型導波路基盤

9-1, 9-2 光入出力導波路部

10-1, 10-2 スラブ導波路部

11 アレー導波路グレーディング部

L-P- i ($i=1, 2, \dots, n$) 光入出力ポートR-P- i ($i=1, 2, \dots, n$) 光入出力ポートS1- j ($j=1, 2, \dots, n$) 光クロスコネク用
スイッチ回路S2- j ($j=1, 2, \dots, n$) 光クロスコネク用 10
スイッチ回路S- j -I- i ($j=1, 2, \dots, n; i=1, 2, 3, 4$) 光入力ポートS- j -O- i ($j=1, 2, \dots, n; i=1, 2, 3, 4$) 光出力ポートS- j -ADD-1, S- j -ADD-2 光入力ポ
ートS- j -DROP-1, S- j -DROP-2 光出力
ポートCS- i ($i=1, 2, \dots, n$) 2入力2出力クロス 20
バー動作光スイッチ回路CS- i -I- j ($i=1, 2, \dots, n; j=1, 2$)
光入力ポートCS- i -O- j ($i=1, 2, \dots, n; j=1, 2$) *

* 光出力ポート

SS- i ($i=1, 2, \dots, n$) 2×1 透過結合ボ
ート選択光スイッチ回路SS- i -I/O-L- j ($i=1, 2, \dots, n; j=1, 2$) 光入出力ポートSS- i -I/O-R-1 光入出力ポートI/O- i ($i=1, 2, 3, 4$) 外部光入出力ポ
ート

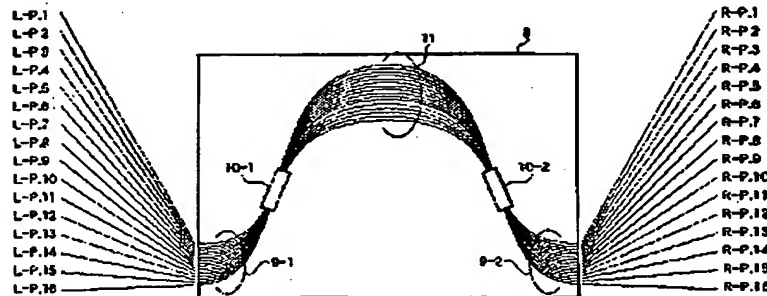
ADD-I-1, ADD-I-2 外部光入力ポート

DROP-O-1, DROP-O-2 外部光出力ポ
ートCL- i ($i=1, 2, 3, 4$) 光サーキュレータ
(3ポート型)CL-I/O- i ($i=1, 2, 3, 4$) 光入出力ポ
ートCL-I- i ($i=1, 2, 3, 4$) 光入力ポートCL-O- i ($i=1, 2, 3, 4$) 光出力ポートAMP- i ($i=1, 2, 3, 4$) 片方向光増幅器
CORE 光回路部A-I/O- i ($i=1, 2, \dots, 12$) 光入出力ポ
ート

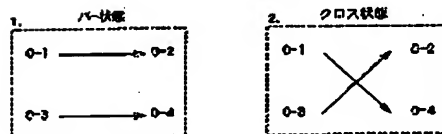
WM-1, WM-2 光波長台分波回路

S3- i 4入力4出力光回路

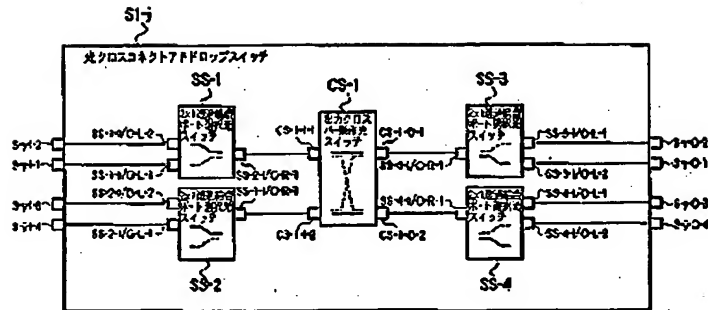
【図1】



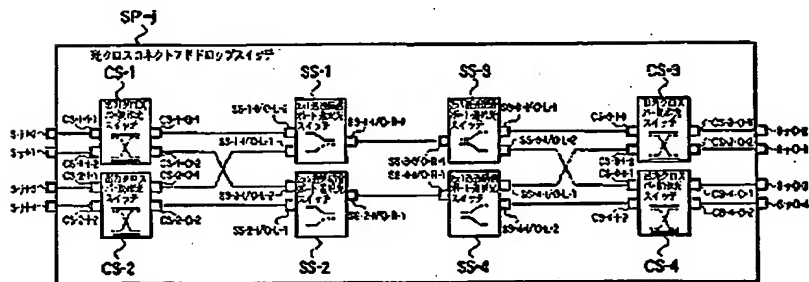
【図6】



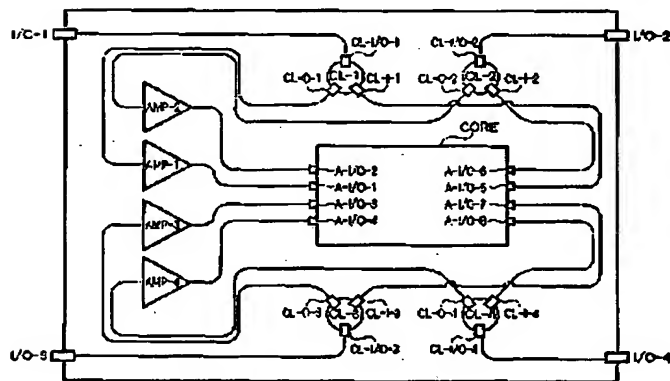
【図2】



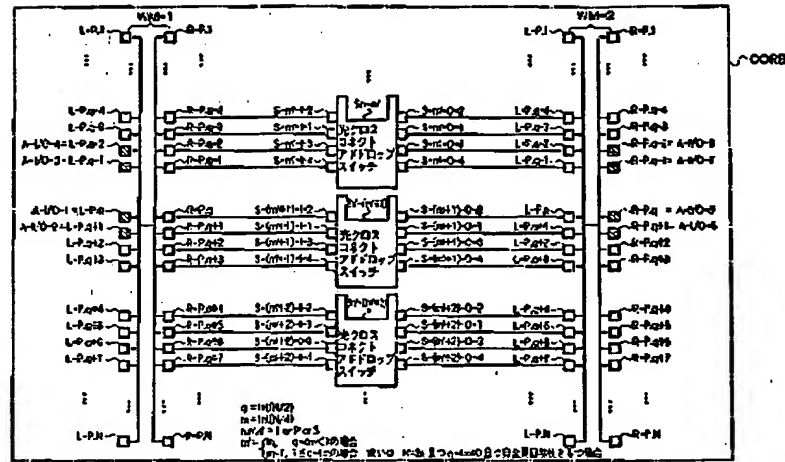
【図3】



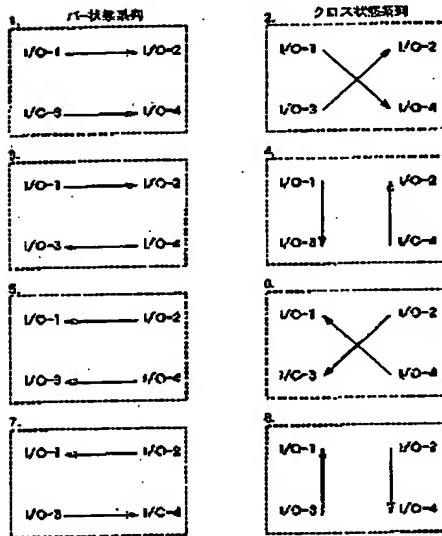
【図4】



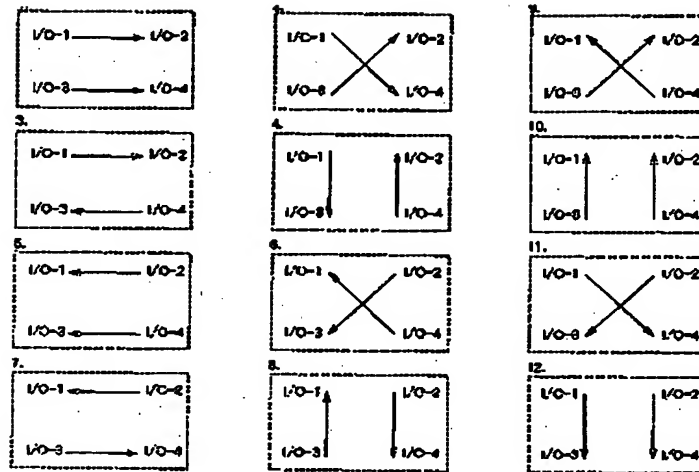
【図5】



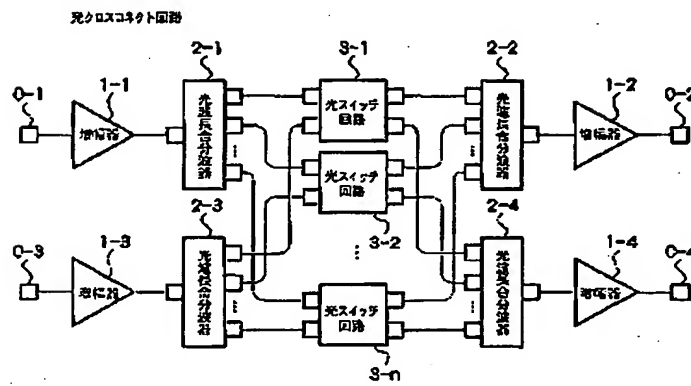
【図7】



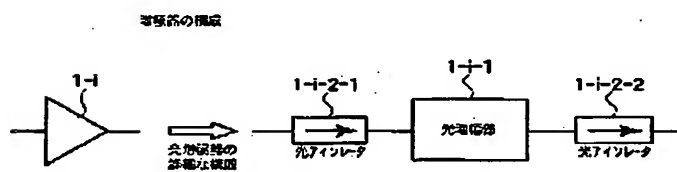
【図8】



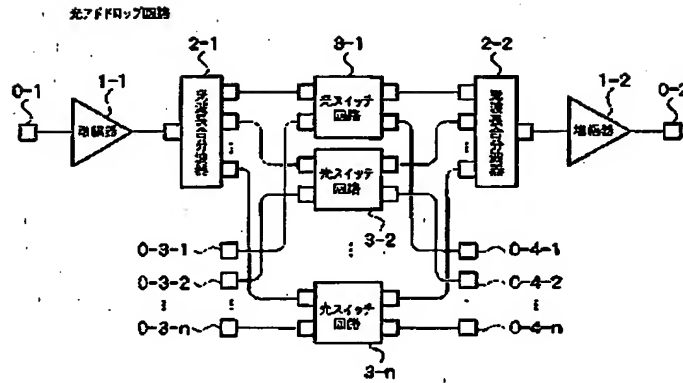
【図9】



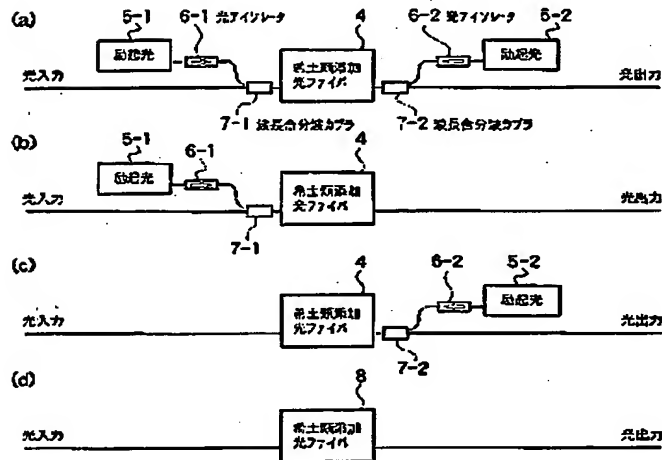
【図11】



【図10】



【図12】



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